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The application was originally filed in English.

(71) *Sökande* *AstraZeneca AB, Södertälje SE*
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PATENT- OCH REGISTRERINGSVERKET
SWEDEN

Postadress/Adress
Box 5055
S-102 42 STOCKHOLM

Telefon/Phone
+46 8 782 25 00
Vx 08-782 25 00

Telex
17978
PATOREG S

Telefax
+46 8 666 02 86
08-666 02 86

NEW SALTS

Field of the Invention

This invention relates to new salts of compounds that inhibit thrombin following administration to mammalian patients, to pharmaceutical compositions containing such salts, and to processes for obtaining them.

Background to the Invention and Prior Art

In the formulation of drug compositions, it is important for the drug substance to be in a form in which it can be conveniently handled and processed. This is of importance, not only from the point of view of obtaining a commercially-viable manufacturing process, but also from the point of view of subsequent manufacture of pharmaceutical formulations comprising the active compound.

Further, in the manufacture of drug compositions, it is important that a reliable, reproducible and constant plasma concentration profile of drug is provided following administration to a patient.

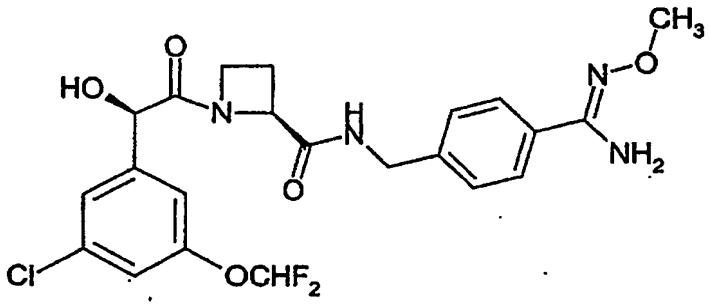
Chemical stability, solid state stability, and "shelf life" of the active ingredients are also very important factors. The drug substance, and compositions containing it, should preferably be capable of being effectively stored over appreciable periods of time, without exhibiting a significant change in the active component's physico-chemical characteristics (e.g. its chemical composition, density, hygroscopicity and solubility).

Moreover, it is also important to be able to provide drug in a form which is as chemically pure as possible.

The skilled person will appreciate that, typically, if a drug can be readily obtained in a stable form, such as a stable crystalline form, advantages may be provided, in terms of ease of handling, ease of preparation of suitable pharmaceutical formulations, and a more reliable solubility profile.

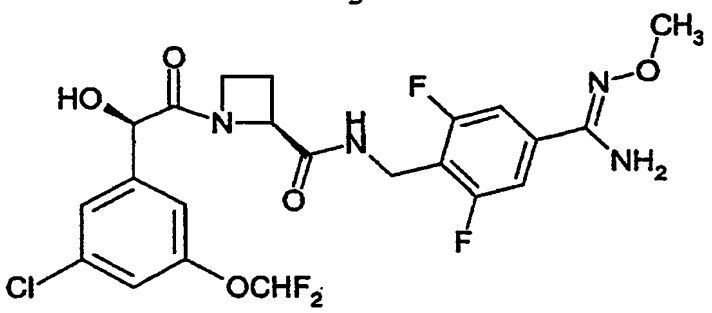
Unpublished international patent application No. PCT/SE01/02657 discloses a number of compounds that are, or are metabolised to compounds which are, competitive inhibitors of trypsin-like proteases, such as thrombin. The following three compounds are amongst those that are specifically disclosed:

(a) Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe):



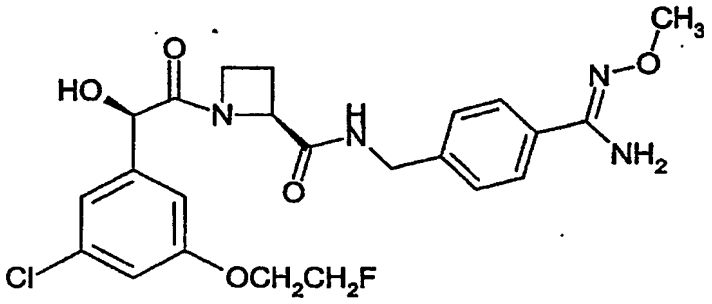
which compound is referred to hereinafter as Compound A;

(b) Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(2,6-diF)(OMe):



which compound is referred to hereinafter as Compound B; and

(c) Ph(3-Cl)(5-OCH_2CH_2F)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe):



which compound is referred to hereinafter as Compound C.

Abbreviations are listed at the end of this specification.

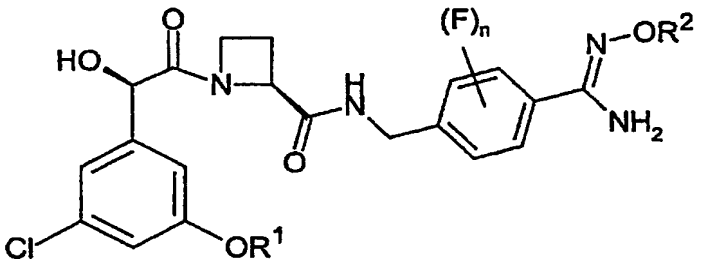
The methoxyamidine Compounds A, B and C are metabolised following oral and/or parenteral administration to the corresponding free amidine compounds, which latter compounds have been found to be potent inhibitors of thrombin.

Processes for the synthesis of Compounds A, B and C are described in Examples 12, 40 and 22 (respectively) of international patent application No. PCT/SE01/02657.

Specific pharmaceutically-acceptable salts of Compounds A, B and C are not disclosed in PCT/SE01/02657. Further, no information is provided in relation to how crystalline forms of Compounds A, B or C, and particularly salts thereof, may be prepared.

Disclosure of the Invention

According to a first aspect of the invention, there is provided a pharmaceutically-acceptable acid addition salt of a compound of formula I,



I

wherein

R^1 represents C_{1-2} alkyl substituted by one or more fluoro substituents;

R^2 represents C_{1-2} alkyl; and

n represents 0, 1 or 2;

which salts are referred to hereinafter as "the compounds of the invention".

The compounds of the invention may be in the form of a solvate, a hydrate, a mixed solvate/hydrate or, preferably, an ansolvate, such as an anhydrate. Solvates may be of one or more organic solvents, such as lower (e.g. C_{1-4})

alkyl alcohols (e.g. methanol, ethanol or *iso*-propanol), ketones (such as acetone), esters (such as ethyl acetate) or mixtures thereof.

Preferred acid addition salts include inorganic acid addition salts, such as those of sulphuric acid, nitric acid, phosphoric acid and hydrohalic acids, such as hydrobromic acid and hydrochloric acid. More preferred acid addition salts include those of organic acids, such as those of dimethylphosphoric acid; saccharinic acid; cyclohexylsulfamic acid; those of carboxylic acids (such as maleic acid, fumaric acid, aspartic acid, succinic acid, malonic acid, acetic acid, benzoic acid, terephthalic acid, hippuric acid, 1-hydroxy-2-naphthoic acid, pamoic acid, hydroxybenzoic acid and the like); those of hydroxy acids (such as salicylic acid, tartaric acid, citric acid, malic acid (including L-(-)-malic acid and, D,L-malic acid), gluconic acid (including D-gluconic acid), glycolic acid, ascorbic acid, lactic acid and the like); those of amino acids (such as glutamic acid (including D-glutamic, L-glutamic, and D,L-glutamic, acids), arginine (including L-arginine), lysine (including L-lysine and L-lysine hydrochloride), glycine and the like); and, particularly, those of sulfonic acids, (such as 1,2-ethanedisulfonic acid, camphorsulfonic acids (including 1S-(+)-10-camphorsulfonic acid and (+/-)-camphorsulfonic acids), ethanesulfonic acid, a propanesulfonic acid (including *n*-propanesulfonic acid), a butanesulfonic acid, a pentanesulfonic acid, a toluenesulfonic acid, methanesulfonic acid, p-xylenesulfonic acid, 2-mesitylenesulfonic acid, naphthalenesulfonic acids (including 1,5-naphthalenesulfonic acid and naphthalenesulfonic acid), benzenesulfonic acid, hydroxybenzenesulfonic acids, 2-hydroxyethanesulfonic acid, 3-hydroxyethanesulfonic acid and the like).

Particularly preferred salts include those of C_{1-6} (e.g. C_{1-4}) alkanesulfonic acids, such as ethanesulfonic acid and propanesulfonic acid (e.g. *n*-propanesulfonic acid) and optionally substituted (e.g. with one or more C_{1-2} alkyl groups) arylsulfonic acids, such as benzenesulfonic acid.

Preferred compounds of formula I include those in which:

R^1 represents $-OCHF_2$ or $-OCH_2CH_2F$;

R^2 represents methyl;

n represents 0 or 2.

More preferred compounds of formula I include those in which n represents 0, or those in which n represents 2, so providing two fluoro atoms located at the 2- and 6-positions (i.e. the two *ortho*-positions relative to the point of attachment of the benzene ring to the $-NH-CH_2-$ group).

Particularly preferred compounds of formula I include Compound B, Compound C and, especially, Compound A.

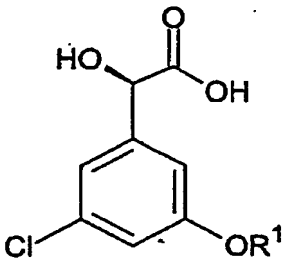
Compounds of the invention may be made by way of techniques, which may comprise addition of an appropriate amount of the relevant acid to a compound of formula I in free base form, for example as described hereinafter; conversion of one salt to another (in the case where there is difference in the pKa values of the relevant acids and the solubilities of the respective salts); and ion pair chromatography.

According to a further aspect of the invention, there is provided a process for the preparation of a compound of the invention, which comprises addition of an acid to a compound of formula I.

Suitable stoichiometric ratios of acid to free base are in the range 0.25:1.5 to 3.0:1, such as 0.45:1.25 to 1.25:1, including 0.50:1 to 1:1.

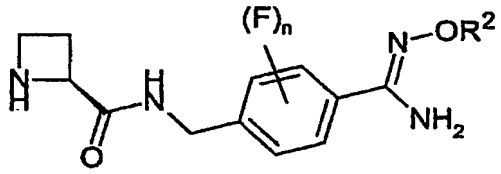
Compounds of formula I may be prepared by:

(i) the coupling of a compound of formula II,



II

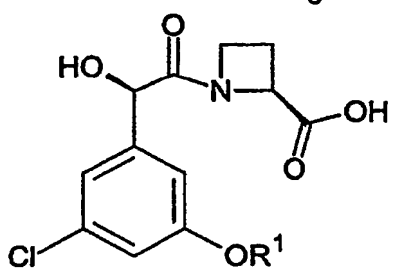
wherein R^1 is as hereinbefore defined with a compound of formula III,



III

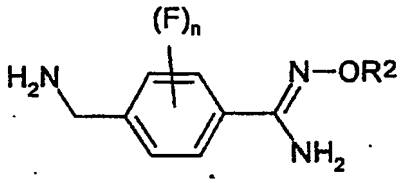
wherein n and R^2 are as hereinbefore defined, for example in the presence of a coupling agent (e.g. oxalyl chloride in DMF, EDC, DCC, HBTU, HATU, PyBOP or TBTU), an appropriate base (e.g. pyridine, DMAP, TEA, 2,4,6-collidine or DIPEA) and a suitable organic solvent (e.g. dichloromethane, acetonitrile, EtOAc or DMF);

(ii) the coupling of a compound of formula IV,



IV

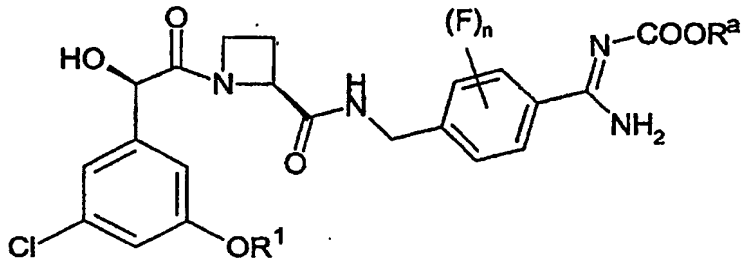
wherein R^1 is as hereinbefore defined with a compound of formula V,



V

wherein n and R^2 are as hereinbefore defined, for example under conditions as described in process (i) above; or

(iii) reaction of a protected derivative of a compound corresponding to a compound of formula I, except that, in place of the group OR^2, a H atom is present (i.e. a corresponding free amidine compound), which protected derivative is, for example, a compound of formula VI,



VI

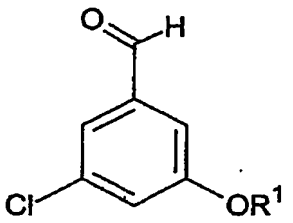
wherein R^a represents, for example, $-CH_2CH_2-Si(CH_3)_3$ or benzyl, and R^1 and n are as hereinbefore defined, or a tautomer thereof, with a compound of formula VII,

$$R^2ONH_2 \qquad \text{VII}$$

wherein R^2 is as hereinbefore defined, or an acid addition salt thereof, for example at between room and reflux temperature in the presence of an appropriate organic solvent (e.g. THF, CH_3CN, DMF or DMSO), followed by removal of the $-C(O)OR^a$ group under conditions known to those skilled in the art (e.g. by reacting with QF or TFA (e.g. as described hereinafter)).

Compounds of formula II are available using known and/or standard techniques.

For example, compounds of formula II may be prepared by reaction of an aldehyde of formula VIII,



VIII

wherein R^1 is as hereinbefore defined with:

(a) a compound of formula IX,

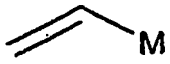
$$R''CN \qquad \text{IX}$$

wherein R" represents H or $(CH_3)_3Si$, for example at room, or elevated, temperature (e.g. below 100°C) in the presence of a suitable organic solvent (e.g. chloroform or methylene chloride) and, if necessary, in the presence of a suitable base (e.g. TEA) and/or a suitable catalyst system (e.g. benzylammonium chloride or zinc iodide, or using a chiral catalyst, for example as described in *Chem. Rev.*, (1999) 99, 3649), followed by hydrolysis under conditions that are well known to those skilled in the art (e.g. as described hereinafter);

(b) NaCN or KCN, for example in the presence of $NaHSO_3$ and water, followed by hydrolysis;

(c) chloroform, for example at elevated temperature (e.g. above room temperature but below 100°C) in the presence of a suitable organic solvent (e.g. chloroform) and, if necessary, in the presence of a suitable catalyst system (e.g. benzylammonium chloride), followed by hydrolysis;

(d) a compound of formula X,

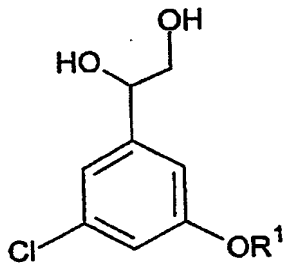


X

wherein M represents Mg or Li, followed by oxidative cleavage (e.g. ozonolysis or osmium or ruthenium catalysed) under conditions which are well known to those skilled in the art; or

(e) tris(methylthio)methane under conditions which are well known to those skilled in the art, followed by hydrolysis in the presence of e.g. HgO and HBF_4.

Compounds of formula II may alternatively be prepared by oxidation of a compound of formula XI,



XI

or a derivative thereof that is optionally protected at the secondary hydroxyl group, wherein R^1 is as hereinbefore defined, in the presence of a suitable oxidising agent (e.g. a combination of a suitable free radical oxidant (such as TEMPO) and an appropriate hypochlorite salt (such as sodium hypochlorite)) under conditions known to those skilled in the art, for example at between -10°C and room temperature, in the presence of a suitable solvent (e.g. water, acetone or a mixture thereof), an appropriate salt (e.g. an alkali metal halide such as potassium bromide) and a suitable base (e.g. an alkali metal carbonate or hydrogen carbonate such as sodium hydrogen carbonate).

In the formation of compounds of formula II, the skilled person will appreciate that the required enantiomeric form may be prepared by way of routine enantiomeric separation techniques, for example by an enantiospecific derivatisation step. This may be achieved, for example by an enzymatic process. Such enzymatic processes include, for example, transesterification of the α-OH group at between room and reflux temperature (e.g. at between 45 and 65°C) in the presence of a suitable enzyme (e.g. Lipase PS Amano), an appropriate ester (e.g. vinyl acetate) and

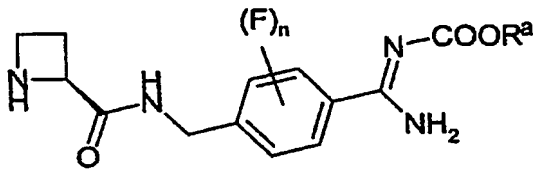
a suitable solvent (e.g. methyl *tert*-butyl ether). The derivatised isomer may then be separated from the unreacted isomer by conventional separation techniques (e.g. chromatography).

Groups added to compounds of formula II in such a derivatisation step may be removed either before any further reactions or at any later stage in the synthesis of compounds of formula I. The additional groups may be removed using conventional techniques (e.g. for esters of the α-OH group, hydrolysis under conditions known to those skilled in the art (e.g. at between room and reflux temperature in the presence of a suitable base (e.g. NaOH) and an appropriate solvent (e.g. MeOH, water or mixtures thereof))).

Compounds of formula III may be prepared by coupling (*S*)-azetidine-2-carboxylic acid to a compound of formula V, as hereinbefore defined, for example under similar conditions to those described herein for preparation of compounds of formula I.

Compounds of formula IV may be prepared by coupling a compound of formula II as hereinbefore defined to (*S*)-azetidine-2-carboxylic acid, for example under similar conditions to those described herein for preparation of compounds of formula I.

Compounds of formula VI may be prepared by reaction of a corresponding compound of formula II, as hereinbefore defined, with a compound of formula XII,



XII

wherein n and R^a are as hereinbefore defined, for example under similar conditions to those described hereinbefore for synthesis of compounds of formula I.

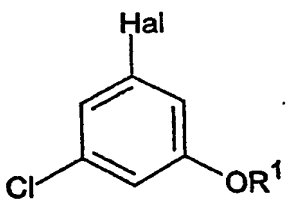
Alternatively, compounds of formula VI may be prepared by reaction of a compound corresponding to a compound of formula I, except that, in place of the group $-OR^2$, a H atom is present (i.e. a corresponding free amidine compound), with a compound of formula XIII,

$$L^1COOR^a \qquad \text{XIII}$$

wherein L^1 represents a suitable leaving group, such as halo or nitrophenyl (e.g. 4-nitrophenyl), and R^a is as hereinbefore defined, for example at or around room temperature in the presence of suitable base (e.g. NaOH, for example in aqueous solution) and an appropriate organic solvent (e.g. methylene chloride).

Compounds of formula VIII are available using known and/or standard techniques. For example, they may be prepared by:

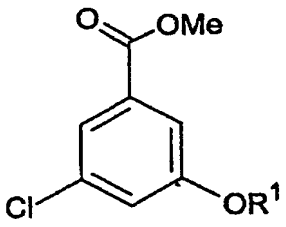
(i) metallation (wherein the metal may be, for example, an alkali metal such as Li or, preferably, a divalent metal such as Mg) of a compound of formula XIV,



XIV

wherein Hal represents a halogen atom selected from Cl, Br and I and R^1 is as hereinbefore defined, followed by reaction with a suitable source of the formyl group (such as *N*,*N*-dimethylformamide), for example under conditions described hereinafter;

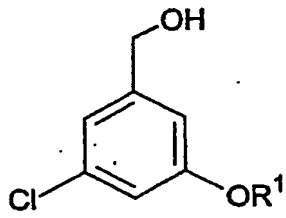
(ii) reduction of a compound of formula XV,



XV

wherein R^1 is as hereinbefore defined in the presence of a suitable reducing agent (e.g. DIBAL-H); or

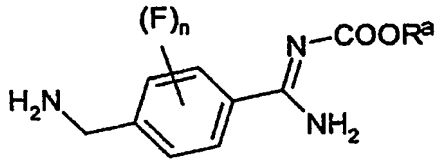
(iii) oxidation of a compound of formula XVI,



XVI

wherein R^1 is as hereinbefore defined in the presence of a suitable oxidising agent (e.g. MnO_2, pyridinium chlorochromate, a combination of DMSO and oxalyl chloride, or SO_3 pyridine complex in DMSO).

Compounds of formula XII may be prepared by reaction of (*S*)-azetidine-2-carboxylic acid with a compound of formula XVII,



XVII

wherein n and R^a are as hereinbefore defined, for example under similar conditions to those described hereinbefore for synthesis of compounds of formula I.

Compounds of formula V, VII, IX, X, XI, XIII, XIV, XV, XVI, XVII and (*S*)-azetidine-2-carboxylic acid are either commercially available, are known in the literature, or may be obtained either by analogy with the processes described herein, or by conventional synthetic procedures, in accordance with standard techniques, from readily available starting materials using appropriate reagents and reaction conditions. Free amidine equivalents of compounds of formula I may be prepared in analogous fashion to processes described herein for preparation of compounds of formula I.

We have found that certain compounds of the invention have the advantage that they may be prepared in crystalline form.

According to a further aspect of the invention there is provided a compound of the invention in substantially crystalline form.

Although we have found that it is possible to produce compounds of the invention in forms which are greater than 80% crystalline, by "substantially crystalline" we include greater than 20%, preferably greater than 30%, and

more preferably greater than 40% (e.g. greater than any of 50, 60, 70, 80 or 90%) crystalline. The degree (%) of crystallinity may be determined by the skilled person using X-ray powder diffraction (XRPD). Other techniques, such as solid state NMR, FT-IR, Raman spectroscopy, differential scanning calorimetry (DSC) and microcalorimetry, may also be used.

Compounds of the invention, and particularly crystalline compounds of the invention, may have improved stability when compared to compounds disclosed in PCT/SE01/02657.

The term "stability" as defined herein includes chemical stability and solid state stability.

By "chemical stability", we include that it may be possible to store compounds of the invention in an isolated form, or in the form of a formulation in which it is provided in admixture with pharmaceutically acceptable carriers, diluents or adjuvants (e.g. in an oral dosage form, such as a tablet, capsule etc.), under normal storage conditions, with an insignificant degree of chemical degradation or decomposition.

By "solid state stability", we include that it may be possible to store compounds of the invention in an isolated solid form, or in the form of a solid formulation in which it is provided in admixture with pharmaceutically acceptable carriers, diluents or adjuvants (e.g. in an oral dosage form, such as a tablet, capsule etc.), under normal storage conditions, with an insignificant degree of solid state transformation (e.g. crystallisation, recrystallisation, solid state phase transition, hydration, dehydration, solvatisation or desolvatisation).

Examples of "normal storage conditions" include temperatures of between minus 80 and plus 50°C (preferably between 0 and 40°C and more preferably room temperatures, such as 15 to 30°C), pressures of between 0.1 and 2 bars (preferably at atmospheric pressure), relative humidities of between 5 and 95% (preferably 10 to 60%), and/or exposure to 460 lux of UV/visible light, for prolonged periods (i.e. greater than or equal to six months). Under such conditions, compounds of the invention may be found to be less than 15%, more preferably less than 10%, and especially less than 5%, chemically degraded/decomposed, or solid state transformed, as appropriate. The skilled person will appreciate that the above-mentioned upper and lower limits for temperature, pressure and relative humidity represent extremes of normal storage conditions, and that certain combinations of these extremes will not be experienced during normal storage (e.g. a temperature of 50°C and a pressure of 0.1 bar).

Preferred compounds of the invention that may be prepared in crystalline form include salts of C_{1-6} (e.g. C_{2-6}, such as C_{2-4}) alkanesulfonic acids, such as ethanesulfonic acid, propanesulfonic acid (e.g. *n*-propanesufonic acid) and optionally substituted arylsulfonic acids, such as benzenesulfonic acid.

It may be possible to crystallise salts of Compounds A, B and C with or without the presence of a solvent system (e.g. crystallisation may be from a melt, under supercritical conditions, or achieved by sublimation). However, we prefer that crystallisation occurs from an appropriate solvent system.

Appropriate solvent systems that may be used in a crystallisation process may be heterogeneous or homogeneous and may thus comprise one or more organic solvents, such as lower alkyl acetates (e.g. linear or branched C_{1-6}

alkyl acetates, such as ethyl acetate, *iso*-propyl acetate and butyl acetate); lower (e.g. linear or branched C_{1-6}) alkyl alcohols, such as hexan-1-ol, 3-methylbutan-1-ol, pentan-1-ol, pentan-2-ol, 4-methyl-2-pentanol and 2-methyl-1-propanol, methanol, ethanol, *n*-propanol, *iso*-propanol and butanol (e.g. *n*-butanol); aliphatic hydrocarbons (e.g. linear or branched C_{5-8} alkanes, such as *n*-pentane, *n*-heptane and *iso*-octane); aromatic hydrocarbons (e.g. benzene, toluene, *o*-xylene, *m*-xylene and *p*-xylene); chlorinated alkanes (e.g. chloroform and dichloromethane); dialkyl (e.g. di-C_{1-6} alkyl) ketones (e.g. acetone, methyl *iso*-butyl ketone), acetonitrile, dimethylformamide, dialkyl ethers (e.g. diethyl ether, di-*iso*-propyl ether, di-*n*-propyl ether, di-*n*-butyl ether and *tert*-butyl methyl ether); and/or aqueous solvents, such as water. Mixtures of any of the above-mentioned solvents may be used.

Different salts may have different solubilities in any given solvent at any given temperature. In this respect, compounds of the invention may be readily soluble in certain solvents (including some of those mentioned above), yet may be less soluble in others. Solvents in which compounds are the invention are poorly soluble may be termed "antisolvents".

Suitable solvents in which compounds of the invention may be readily soluble include lower alkyl alcohols (such as methanol, ethanol and *iso*-propanol). Lower alkyl acetates (such as ethyl acetate and *iso*-propyl acetate), lower dialkyl ketones (such as methyl *iso*-butyl ketone), aliphatic hydrocarbons (such as *iso*-octane and *n*-heptane) and aromatic hydrocarbons (such as toluene) may be employed as antisolvents.

Crystallisation of compounds of the invention from an appropriate solvent system may be achieved by attaining supersaturation in a solvent system

comprising compound of the invention (e.g. by cooling, by solvent evaporation and/or *via* the addition of antisolvent).

It is preferred that crystalline compounds of the invention (and particularly crystalline Compounds A, B and C) are provided by one or more of the following methods:

(i) preparation of a compound of the invention in amorphous form, followed by dissolution of that salt in an appropriate solvent system, such as a polar solvent (e.g. a lower alkyl alcohol, a lower alkyl acetate, a lower dialkyl ketone, or a mixture of these solvents), and subsequent crystallisation (optionally initiated by seeding). Crystallisation may be effected in this way by dissolving compound of the invention in a solvent in which it is readily soluble (e.g. a lower alkyl alcohol), followed by addition of antisolvent (e.g. a lower alkyl acetate or a lower di alkyl ketone), or by dissolving compound in a mixture of a solvent in which it is readily soluble and an antisolvent, and subsequent crystallisation; or

(ii) reaction crystallisation (or precipitation), which comprises adding an appropriate amount of acid to a compound of formula I, and then either:-

(a) direct crystallisation, for example from a solvent system that comprises an antisolvent (e.g. a lower alkyl acetate, a lower dialkyl ketone or a hydrocarbon); or

(b) subsequent addition of an appropriate antisolvent to facilitate crystallisation (e.g. formation of compound of the invention in a solvent in which it is readily soluble (e.g. a lower alkyl alcohol), followed by addition of antisolvent (e.g. an acetate, a lower alkyl ketone or a hydrocarbon)),

in both of which processes (a) and (b), acid and/or base may be initially provided in association with the appropriate solvent system, and in both of which processes (a) and (b), crystallisation may be initiated by seeding.

In the case of process (i) above, preferred solvents may include methyl *iso*-butyl ketone, *iso*-propanol, ethyl acetate, *iso*-propyl acetate and mixtures thereof.

In the case of process (ii) above, depending on the salt that is to be formed:
(a) preferred solvents for "direct" crystallisation may include *iso*-propanol, *iso*-propyl acetate, *n*-butyl acetate, toluene or, preferably, methyl *iso*-butyl ketone or ethyl acetate; and
(b) when the crystallisation employs antisolvent, preferred solvents in which compounds of the invention are readily soluble may include methanol, ethanol or, preferably, *iso*-propanol; and preferred antisolvents may include methyl *iso*-butyl ketone, *n*-butyl acetate, toluene, *iso*-octane, *n*-heptane or, preferably, ethyl acetate or *iso*-propyl acetate.

In any of processes (i) or (ii), the skilled person will appreciate that, following salt formation, at least part of the solvent(s) may be removed, and then the resultant mixture re-dissolved prior to performing a crystallisation as described herein.

When the crystalline compound of the invention to be formed is an ethanesulfonate salt of Compound A, and:
(1) the process performed is process (i), amorphous salt may be slurried in either methyl *iso*-butyl ketone or a mixture of *iso*-propanol and ethyl acetate; and
(2) the process performed is process (ii), a direct crystallisation may be achieved by adding ethanesulfonic acid, optionally in the form of a solution in methyl *iso*-butyl ketone, to a solution of Compound A in methyl *iso*-butyl ketone. Alternatively, ethanesulfonic acid may be added to a solution of

Compound A in *iso*-propanol, and ethyl acetate may then be added as antisolvent.

When the crystalline compound of the invention to be formed is an *n*-propanesulfonate salt of Compound A, and:

(I) the process performed is process (i), amorphous salt may be slurried in a mixture of *iso*-propanol and *iso*-propyl acetate, or in a mixture of *iso*-propanol and ethyl acetate; and

(II) the process performed is process (ii), *n*-propanesulfonic acid may be added to a solution of Compound A in *iso*-propanol and then ethyl acetate, or *iso*-propyl acetate, added as antisolvent.

When the crystalline compound of the invention to be formed is a benzenesulfonate salt of Compound A, and:

(A) the process performed is process (i), amorphous salt may be slurried in ethyl acetate, methyl *iso*-butyl ketone or *iso*-propyl acetate; and

(B) the process performed is process (ii), benzenesulfonic acid may be added to a solution of Compound A in ethyl acetate, and then a small amount of *iso*-propanol added to facilitate transformation into crystalline material. Alternatively, benzenesulfonic acid may be added to a solution of Compound A in *iso*-propanol, and then ethyl acetate added as antisolvent.

According to a further aspect of the invention, there is provided a process for the preparation of a crystalline compound of the invention which comprises crystallising a compound of the invention from an appropriate solvent system.

Crystallisation temperatures and crystallisation times depend upon the salt that is to be crystallised, the concentration of that salt in solution, and the solvent system which is used.

Crystallisation may also be initiated and/or effected by way of standard techniques, for example with or without seeding with crystals of the appropriate crystalline compound of the invention.

Compounds of the invention that are anhydrates contain no more than 3%, preferably 2%, more preferably 1% and more preferably 0.5% (w/w) water, whether such water is bound (crystal water or otherwise) or not.

Different crystalline forms of the compounds of the invention may be readily characterised using X-ray powder diffraction (XRPD) methods, for example as described hereinafter.

In order to ensure that a particular crystalline form is prepared in the absence of other crystalline forms, crystallisations are preferably carried out by seeding with nuclei and/or seed crystals of the desired crystalline form in substantially complete absence of nuclei and/or seed crystals of other crystalline forms. Seed crystals of appropriate compound may be prepared, for example, by way of slow evaporation of solvent from a portion of solution of appropriate salt.

Compounds of the invention may be isolated using techniques which are well known to those skilled in the art, for example decanting, filtering or centrifuging.

Compounds may be dried using standard techniques.

Further purification of compounds of the invention may be effected using techniques, which are well known to those skilled in the art. For example impurities may be removed by way of recrystallisation from an appropriate solvent system. Suitable temperatures and times for the recrystallisation depend upon the concentration of the salt in solution, and upon the solvent system which is used.

When compounds of the invention are crystallised, or recrystallised, as described herein, the resultant salt may be in a form which has improved chemical and/or solid state stability, as mentioned hereinbefore.

Pharmaceutical Preparations and Medical Uses

Compounds of the invention may be administered parenterally or orally to mammalian patients (including humans), and may thereafter be metabolised in the body to form compounds that are pharmacologically active (i.e. they act as "prodrugs" of active compounds).

Thus, the compounds of the invention are useful because they are metabolised in the body following oral or parenteral administration to form compounds which possess pharmacological activity. The compounds of the invention are therefore indicated as pharmaceuticals.

According to a further aspect of the invention there is thus provided the compounds of the invention for use as pharmaceuticals.

In particular, compounds of the invention are metabolised following administration to form potent inhibitors of thrombin, for example as may be

demonstrated in the tests described in *inter alia* international patent application No. PCT/SE01/02657, as well as international patent applications WO 02/14270, WO 01/87879 and WO 00/42059, the relevant disclosures in which documents are hereby incorporated by reference.

By "prodrug of a thrombin inhibitor", we include compounds that form a thrombin inhibitor, in an experimentally-detectable amount, and within a predetermined time (e.g. about 1 hour), following oral or parenteral administration.

The compounds of the invention are thus expected to be useful in those conditions where inhibition of thrombin is required, and/or conditions where anticoagulant therapy is indicated, including the following:

The treatment and/or prophylaxis of thrombosis and hypercoagulability in blood and/or tissues of animals including man. It is known that hypercoagulability may lead to thrombo-embolic diseases. Conditions associated with hypercoagulability and thrombo-embolic diseases which may be mentioned include inherited or acquired activated protein C resistance, such as the factor V-mutation (factor V Leiden), and inherited or acquired deficiencies in antithrombin III, protein C, protein S, heparin cofactor II. Other conditions known to be associated with hypercoagulability and thrombo-embolic disease include circulating antiphospholipid antibodies (Lupus anticoagulant), homocysteinemi, heparin induced thrombocytopenia and defects in fibrinolysis, as well as coagulation syndromes (e.g. disseminated intravascular coagulation (DIC)) and vascular injury in general (e.g. due to surgery).

The treatment of conditions where there is an undesirable excess of thrombin without signs of hypercoagulability, for example in neurodegenerative diseases such as Alzheimer's disease.

Particular disease states which may be mentioned include the therapeutic and/or prophylactic treatment of venous thrombosis (e.g. DVT) and pulmonary embolism, arterial thrombosis (e.g. in myocardial infarction, unstable angina, thrombosis-based stroke and peripheral arterial thrombosis), and systemic embolism usually from the atrium during atrial fibrillation (e.g. non-valvular atrial fibrillation) or from the left ventricle after transmural myocardial infarction, or caused by congestive heart failure; prophylaxis of re-occlusion (i.e. thrombosis) after thrombolysis, percutaneous trans-luminal angioplasty (PTA) and coronary bypass operations; the prevention of re-thrombosis after microsurgery and vascular surgery in general.

Further indications include the therapeutic and/or prophylactic treatment of disseminated intravascular coagulation caused by bacteria, multiple trauma, intoxication or any other mechanism; anticoagulant treatment when blood is in contact with foreign surfaces in the body such as vascular grafts, vascular stents, vascular catheters, mechanical and biological prosthetic valves or any other medical device; and anticoagulant treatment when blood is in contact with medical devices outside the body such as during cardiovascular surgery using a heart-lung machine or in haemodialysis; the therapeutic and/or prophylactic treatment of idiopathic and adult respiratory distress syndrome, pulmonary fibrosis following treatment with radiation or chemotherapy, septic shock, septicemia, inflammatory responses, which include, but are not limited to, edema, acute or chronic atherosclerosis such as coronary arterial disease and the formation of atherosclerotic plaques, cerebral arterial

disease, cerebral infarction, cerebral thrombosis, cerebral embolism, peripheral arterial disease, ischaemia, angina (including unstable angina), reperfusion damage, restenosis after percutaneous trans-luminal angioplasty (PTA) and coronary artery bypass surgery.

Compounds of the invention that inhibit trypsin and/or thrombin may also be useful in the treatment of pancreatitis.

The compounds of the invention are thus indicated both in the therapeutic and/or prophylactic treatment of these conditions.

According to a further aspect of the present invention, there is provided a method of treatment of a condition where inhibition of thrombin is required which method comprises administration of a therapeutically effective amount of a compound of the invention to a person suffering from, or susceptible to, such a condition.

The compounds of the invention will normally be administered orally, intravenously, subcutaneously, buccally, rectally, dermally, nasally, tracheally, bronchially, by any other parenteral route or *via* inhalation, in the form of pharmaceutical preparations comprising compound of the invention in a pharmaceutically acceptable dosage form.

Depending upon the disorder and patient to be treated and the route of administration, the compositions may be administered at varying doses.

The compounds of the invention may also be combined and/or co-administered with any antithrombotic agent(s) with a different mechanism of action, such as one or more of the following: the antiplatelet agents

acetylsalicylic acid, ticlopidine and clopidogrel; thromboxane receptor and/or synthetase inhibitors; fibrinogen receptor antagonists; prostacyclin mimetics; phosphodiesterase inhibitors; ADP-receptor (P_2T) antagonists; and inhibitors of carboxypeptidase U (CPU).

The compounds of the invention may further be combined and/or co-administered with thrombolytics such as one or more of tissue plasminogen activator (natural, recombinant or modified), streptokinase, urokinase, prourokinase, anisoylated plasminogen-streptokinase activator complex (APSAC), animal salivary gland plasminogen activators, and the like, in the treatment of thrombotic diseases, in particular myocardial infarction.

According to a further aspect of the invention there is provided a pharmaceutical formulation including a compound of the invention, in admixture with a pharmaceutically acceptable adjuvant, diluent or carrier.

Suitable daily doses of the compounds of the invention in therapeutic treatment of humans are about 0.001-100 mg/kg body weight at peroral administration and 0.001-50 mg/kg body weight at parenteral administration, excluding the weight of any acid counter-ion.

For the avoidance of doubt, as used herein, the term "treatment" includes therapeutic and/or prophylactic treatment.

Compounds of the invention have the advantage that they may be more efficacious, be less toxic, be longer acting, have a broader range of activity, be more potent, produce fewer side effects, be more easily absorbed, and/or have a better pharmacokinetic profile (e.g. higher oral bioavailability and/or lower clearance), than, and/or have other useful pharmacological, physical,

or chemical, properties over, compounds known in the prior art. Compounds of the invention may have the further advantage that they may be administered less frequently than compounds known in the prior art.

Compounds of the invention may also have the advantage that they are in a form which provides for improved ease of handling. Further, compounds of the invention have the advantage that they may be produced in forms which may have improved chemical and solid state stability (including e.g. lower hygroscopicity). Thus, such compounds of the invention may be stable when stored over prolonged periods.

Compounds of the invention may also have the advantage that they may be crystallised in good yields, in a high purity, rapidly, conveniently, and at a low cost.

The invention is illustrated, but in no way limited, by the following examples, with reference to the enclosed figures in which:

Figure 1 shows an X-ray powder diffractogram for crystalline Compound A, ethanesulfonic acid salt.

Figure 2 shows an X-ray powder diffractogram for crystalline Compound A, benzenesulfonic acid salt.

Figure 3 shows an X-ray powder diffractogram for crystalline Compound A, *n*-propanesulfonic acid salt.

General Procedures

TLC was performed on silica gel. Chiral HPLC analysis was performed using a 46 mm X 250 mm Chiralcel OD column with a 5 cm guard column. The column temperature was maintained at 35°C. A flow rate of 1.0 mL/min was used. A Gilson 115 UV detector at 228 nm was used. The mobile phase consisted of hexanes, ethanol and trifluroacetic acid and the appropriate ratios are listed for each compound. Typically, the product was dissolved in a minimal amount of ethanol and this was diluted with the mobile phase.

In Preparations A to C below, LC-MS/MS was performed using a HP-1100 instrument equipped with a CTC-PAL injector and a 5 μm, 4x100 mm ThermoQuest, Hypersil BDS-C18 column. An API-3000 (Sciex) MS detector was used. The flow rate was 1.2 mL/min and the mobile phase (gradient) consisted of 10-90% acetonitrile with 90-10% of 4 mM aq. ammonium acetate, both containing 0.2% formic acid. Otherwise, low resolution mass spectra (LRMS) were recorded using a Micromass ZQ spectrometer in ESI posneg switching ion mode (mass range m/z 100-800); and high resolution mass spectra (HRMS) were recorded using a Micromass LCT spectrometer in ES negative ionization mode (mass range m/z 100-1000) with Leucine Enkephalin ($C_{28}H_{37}N_5O_7$) as internal mass standard.

^1H NMR spectra were recorded using tetramethylsilane as the internal standard. ^{13}C NMR spectra were recorded using the listed deuterated solvents as the internal standard. Otherwise, MeOD was used as solvent and the MeOD signal as internal standard (^1H $\delta = 3.30$ ppm; ^{13}C $\delta = 49$ ppm).

X-ray powder diffraction analysis (XRPD) was performed using variable slits on samples prepared according to standard methods without using any internal standard, for example those described in Giacovazzo, C. *et al* (1995), *Fundamentals of Crystallography*, Oxford University Press; Jenkins, R. and Snyder, R. L. (1996), *Introduction to X-Ray Powder Diffractometry*, John Wiley & Sons, New York; Bunn, C. W. (1948), *Chemical Crystallography*, Clarendon Press, London; or Klug, H. P. & Alexander, L. E. (1974), *X-ray Diffraction Procedures*, John Wiley and Sons, New York. X-ray analyses were performed using a Siemens D5000 diffractometer.

Differential scanning calorimetry (DSC) was performed using a Mettler DSC820 instrument, according to standard methods, for example those described in Höhne, G. W. H. *et al* (1996), *Differential Scanning Calorimetry*, Springer, Berlin.

Thermogravimetric analysis (TGA) was performed using a Mettler Toledo TGA850 instrument.

It will be appreciated by the skilled person that crystalline forms of compounds of the invention may be prepared by analogy with processes described herein and/or in accordance with the Examples below, and may show essentially the same XRPD diffraction patterns and/or DSC and/or TGA thermograms as those disclosed herein. By "essentially the same" XRPD diffraction patterns and/or DSC and/or TGA thermograms, we include those instances when it is clear from the relevant patterns and/or thermograms (allowing for experimental error) that essentially the same crystalline form has been formed. When provided, DSC onset temperatures may vary in the range ±5°C (e.g. ±2°C), and XRPD distance values may vary in the range ±2 on the last decimal place. It will be appreciated by the

skilled person that XRPD intensities may vary when measured for essentially the same crystalline form for a variety of reasons including, for example, preferred orientation.

Preparation A

Preparation of Compound A

(i) 3-Chloro-5-methoxybenzaldehyde

3,5-Dichloroanisole (74.0 g, 419 mmol) in THF (200 mL) was added dropwise to magnesium metal (14.2 g, 585 mmol, pre-washed with 0.5 N HCl) in THF (100 mL) at 25°C. After the addition, 1,2-dibromoethane (3.9 g, 20.8 mmol) was added dropwise. The resultant dark brown mixture was heated at reflux for 3 h. The mixture was cooled to 0°C, and *N,N*-dimethylformamide (60 mL) was added in one portion. The mixture was partitioned with diethyl ether (3 x 400 mL) and 6N HCl (500 mL). The combined organic extracts were washed with brine (300 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo* to give an oil. Flash chromatography (2x) on silica gel eluting with Hex:EtOAc (4:1) afforded the sub-title compound (38.9 g, 54%) as a yellow oil.

^1H NMR (300 MHz, $CDCl_3$) δ 9.90 (s, 1H), 7.53 (s, 1H), 7.38 (s, 1H), 7.15 (s, 1H), 3.87 (s, 3H).

(ii) 3-Chloro-5-hydroxybenzaldehyde

A solution of 3-chloro-5-methoxybenzaldehyde (22.8 g, 134 mmol; see step (i) above) in CH_2Cl_2 (250 mL) was cooled to 0°C. Boron tribromide (15.8 mL, 167 mmol) was added dropwise over 15 min. After stirring, the reaction mixture for 2 h, H_2O (50 mL) was added slowly. The solution was then extracted with Et_2O (2 x 100 mL). The organic layers were combined,

dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash chromatography on silica gel eluting with Hex:EtOAc (4:1) afforded the sub-title compound (5.2 g, 25%).

^1H NMR (300 MHz, $CDCl_3$) δ 9.85 (s, 1H), 7.35 (s,1H), 7.20 (s,1H), 7.10 (s,1H), 3.68 (s,1H)

(iii) 3-Chloro-5-difluoromethoxybenzaldehyde

A solution of 3-chloro-5-hydroxybenzaldehyde (7.5g, 48 mmol; see step (ii) above) in 2-propanol (250 mL) and 30% KOH (100 mL) was heated to reflux. While stirring, $CHClF_2$ was bubbled into the reaction mixture for 2 h. The reaction mixture was cooled, acidified with 1N HCl and extracted with EtOAc (2 x 100 mL). The organics were washed with brine (100 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo*. Flash chromatography on silica gel eluting with Hex:EtOAc (4:1) afforded the sub-title compound (4.6 g, 46%).

^1H NMR (300 MHz, $CDCl_3$) δ 9.95 (s, 1H), 7.72 (s, 1H), 7.52 (s, 1H), 7.40 (s, 1H), 6.60 (t, J_{H-F} = 71.1 Hz, 1H)

(iv) Ph(3-Cl)(5-$OCHF_2$)-(*R*,*S*)CH(OTMS)CN

A solution of 3-chloro-5-difluoromethoxybenzaldehyde (4.6 g, 22.3 mmol; see step (iii) above) in CH_2Cl_2 (200 mL) was cooled to 0°C. ZnI_2 (1.8 g, 5.6 mmol) and trimethylsilyl cyanide (2.8 g, 27.9 mmol) were added and the reaction mixture was allowed to warm to room temperature and stirred for 15 h. The mixture was partially concentrated *in vacuo* yielding the sub-title compound as a liquid, which was used directly in step (v) below without further purification or characterization.

(v) Ph(3-Cl)(5-$OCHF_2$)-(*R*,*S*)CH(OH)C(NH)OEt

Ph(3-Cl)(5-$OCHF_2$)-(*R*,*S*)CH(OTMS)CN (6.82 g, assume 22.3 mmol; see step (iv) above) was added dropwise to HCl/EtOH (500 mL). The reaction mixture was stirred 15 h, then partially concentrated *in vacuo* yielding the sub-title compound as a liquid, which was used in step (vi) without further purification or characterization.

(vi) Ph(3-Cl)(5-$OCHF_2$)-(*R*,*S*)CH(OH)C(O)OEt

Ph(3-Cl)(5-$OCHF_2$)-(*R*,*S*)CH(OH)C(NH)OEt (6.24 g, assume 22.3 mmol; see step (v) above) was dissolved in THF (250 mL), 0.5M H_2SO_4 (400 mL) was added and the reaction was stirred at 40°C for 65 h, cooled and then partially concentrated *in vacuo* to remove most of the THF. The reaction mixture was then extracted with Et_2O (3 x 100 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford the sub-title compound as a solid, which was used in step (vii) without further purification or characterization.

(vii) Ph(3-Cl)(5-$OCHF_2$)-(*R*,*S*)CH(OH)C(O)OH

A solution of Ph(3-Cl)(5-$OCHF_2$)-(*R*,*S*)CH(OH)C(O)OEt (6.25 g, assume 22.3 mmol; see step (vi) above) in 2-propanol (175 mL) and 20% KOH (350 mL) was stirred at room temperature 15 h. The reaction was then partially concentrated *in vacuo* to remove most of the 2-propanol. The remaining mixture was acidified with 1M H_2SO_4, extracted with Et_2O (3 x 100 mL), dried (Na_2SO_4) and concentrated *in vacuo* to give a solid. Flash chromatography on silica gel eluting with $CHCl_3$:MeOH:concentrated NH_4OH (6:3:1) afforded the ammonium salt of the sub-title compound. The ammonium salt was then dissolved in a mixture of EtOAc (75 mL) and H_2O (75 mL) and acidified with 2N HCl. The organic layer was separated

and washed with brine (50 mL), dried (Na_2SO_4) and concentrated *in vacuo* to afford the sub-title compound (3.2 g, 57% from steps (iv) to (vii)).

^1H NMR (300 MHz, CD_3OD) δ 7.38 (s, 1H), 7.22 (s, 1H), 7.15 (s, 1H), 6.89 (t, J_{H-F} = 71.1 Hz, 1H), 5.16 (s, 1H)

(viii) Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)OH (a) and Ph(3-Cl)(5-$OCHF_2$)-(*S*)CH(OAc)C(O)OH (b)

A mixture of Ph(3-Cl)(5-$OCHF_2$)-(*R,S*)CH(OH)C(O)OH (3.2 g, 12.7 mmol; see step (vii) above) and Lipase PS "Amano" (~2.0 g) in vinyl acetate (125 mL) and MTBE (125 mL) was heated at reflux for 48 h. The reaction mixture was cooled, filtered through Celite® and the filter cake washed with EtOAc. The filtrate was concentrated *in vacuo* and subjected to flash chromatography on silica gel eluting with $CHCl_3$:MeOH:concentrated NH_4OH (6:3:1) yielding the ammonium salts of the sub-title compounds (a) and (b). Compound (a) as a salt was dissolved in H_2O, acidified with 2N HCl and extracted with EtOAc. The organic layer was washed with brine, dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford the sub-title compound (a) (1.2 g, 37%).

For sub-title compound (a)

^1H NMR (300 MHz, CD_3OD) δ 7.38 (s, 1H), 7.22 (s, 1H), 7.15 (s, 1H), 6.89 (t, J_{H-F} = 71.1 Hz, 1H), 5.17 (s, 1H)

(ix) Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-Aze-Pab(Teoc)

To a solution of Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)OH (1.1 g, 4.4 mmol; see step (viii) above) and H-Aze-Pab(Teoc) (see international patent application WO 00/42059, 2.6 g, 5.7 mmol) in DMF (50 mL) at 0°C was added PyBOP (2.8 g, 5.3 mmol) and collidine (1.3 g, 10.6 mmol). The

reaction was stirred at 0°C for 2 h and then at room temperature for an additional 15 h. The reaction mixture was concentrated *in vacuo* and flash chromatographed on silica gel (3 x), eluting first with $CHCl_3$:EtOH (9:1), then with EtOAc:EtOH (20:1) and finally eluting with CH_2Cl_2:CH_3OH (95:5) to afford the sub-title compound (1.0 g, 37%) as a white solid.

^{1}H NMR (300 MHz, CD_3OD, mixture of rotamers) δ 7.79-7.85 (d, J = 8.7 Hz, 2H), 7.15-7.48 (m, 5H), 6.89 and 6.91 (t, J_{H-F} = 71.1 Hz, 1H), 5.12 and 5.20 (s, 1H), 4.75-4.85 (m, 1H), 3.97-4.55 (m, 6H), 2.10-2.75 (m, 2H), 1.05-1.15 (m, 2H), 0.09 (s, 9H)
MS (m/z) 611 $(M + 1)^+$

(x) Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-Aze-Pab(OMe, Teoc)

Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-Aze-Pab(Teoc) (0.40 g, 0.65 mmol; see step (ix) above), was dissolved in 20 mL of acetonitrile and 0.50 g (6.0 mmol) of O-methyl hydroxylamine hydrochloride was added. The mixture was heated at 70°C for 2 h. The solvent was evaporated and the residue was partitioned between water and ethyl acetate. The aqueous phase was extracted twice more with ethyl acetate and the combined organic phase was washed with water, brine, dried (Na_2SO_4), filtered and evaporated. Yield: 0.41 g (91%).

^{1}H-NMR (400 MHz; $CDCl_3$) : δ 7.83 (bt, 1H), 7.57 (bs, 1H), 7.47 (d, 2H), 7.30 (d, 2H), 7.20 (m, 1H), 7.14 (m, 1H), 7.01 (m, 1H), 6.53 (t, 1H), 4.89 (s, 1H), 4.87 (m, 1H), 4.47 (m, 2H), 4.4-4.2 (b, 1H), 4.17-4.1 (m, 3H), 3.95 (s, 3H), 3.67 (m, 1H), 2.68 (m, 1H), 2.42 (m,1H) 0.97 (m, 2H), 0.01 (s, 9H).

(xi) Compound A

Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-Aze-Pab(OMe, Teoc) (0.40 g, 0.62 mmol; see step (x) above), was dissolved in 5 mL of TFA and allowed to react for 30 min. TFA was evaporated and the residue was partitioned between ethyl acetate and $NaHCO_3$ (aq.). The aqueous phase was extracted twice more with ethyl acetate and the combined organic phase was washed with water, brine, dried (Na_2SO_4), filtered and evaporated. The product was freeze dried from water/acetonitrile. No purification was necessary.Yield: 0.28 g (85%).

^{1}H-NMR (600 MHz; $CDCl_3$) : δ 7.89 (bt, 1H), 7.57 (d, 2H), 7.28 (d, 2H), 7.18 (m, 1H), 7.13 (m,1H), 6.99 (m, 1H), 6.51 (t, 1H), 4.88 (s, 1H), 4.87 (m, 1H), 4.80 (bs, 2H), 4.48 (dd, 1H), 4.43 (dd, 1H), 4.10 (m, 1H), 3.89 (s, 3H), 3.68 (m, 1H), 2.68 (m, 1H), 2.40 (m, 1H).

^{13}C-NMR (125 MHz; $CDCl_3$): (carbonyl and/or amidine carbons, rotamers) δ 172.9, 170.8, 152.7, 152.6

HRMS calculated for $C_{22}H_{23}ClF_2N_4O_5$ $(M-H)^-$ 495.1242, found 495.1247

Preparation B

Preparation of Compound B

(i) 2,6-Difluoro-4[(methylsulfinyl)(methylthio)methyl]benzonitrile

(Methylsulfinyl)(methylthio)methane (7.26g, 0.0584 mol) was dissolved in 100 mL of dry THF under argon and was cooled to –78°C. ·Butyllithium in hexane (16 mL 1.6M, 0.0256 mol) was added dropwise with stirring. The mixture was stirred for 15 min. Meanwhile, a solution of 3,4,5-trifluorobenzonitrile (4.0 g, 0.025 mmol) in 100 mL of dry THF was cooled to -78°C under argon and the former solution was added through a cannula

to the latter solution over a period of 35 min. After 30 min, the cooling bath was removed and when the reaction had reached room temperature it was poured into 400 mL of water. The THF was evaporated and the remaining aqueous layer was extracted three times with diethyl ether. The combined ether phase was washed with water, dried (Na_2SO_4) and evaporated. Yield: 2.0 g (30%).

^1H NMR (500 MHz, $CDCl_3$) δ 7.4-7.25 (m, 2H), 5.01 (s, 1H, diasteromer), 4.91 (s, 1H, diasteromer), 2.88 (s, 3H, diasteromer), 2.52 (s, 3H, diasteromer), 2.49 (s, 3H, diasteromer), 2.34 (s, 3H, diasteromer), 1.72 (broad, 1H)

(ii) 2,6-Difluoro-4-formylbenzonitrile

2,6-Difluoro-4[(methylsulfinyl)(methylthio)methyl]benzonitrile (2.17 g, 8.32 mmol; see step (i) above) was dissolved in 90 mL of THF and 3.5 mL of concentrated sulfuric acid was added. The mixture was left at room temperature for 3 days and subsequently poured into 450 mL of water. Extraction three times with EtOAc followed and the combined ethereal phase was washed twice with aqueous sodium bicarbonate and with brine, dried (Na_2SO_4) and evaporated. Yield: 1.36 g (98%). The position of the formyl group was established by ^{13}C NMR. The signal from the fluorinated carbons at 162.7 ppm exhibited the expected coupling pattern with two coupling constants in the order of 260 Hz and 6.3 Hz respectively corresponding to an *ipso* and a *meta* coupling from the fluorine atoms.

^1H NMR (400 MHz, $CDCl_3$) δ 10.35 (s, 1H), 7.33 (m, 2H)

(iii) 2,6-Difluoro-4-hydroxymethylbenzonitrile

2,6-Difluoro-4-formylbenzonitrile (1.36 g, 8.13 mmol; see step (ii) above) was dissolved in 25 mL of methanol and cooled on an ice bath. Sodium borohydride (0.307 g, 8.12 mmol) was added in portions with stirring and the reaction was left for 65 min. The solvent was evaporated and the residue was partitioned between diethyl ether and aqueous sodium bicarbonate. The ethereal layer was washed with more aqueous sodium bicarbonate and brine, dried (Na_2SO_4) and evaporated. The crude product crystallised soon and could be used without further purification. Yield: 1.24 g (90%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 (m, 2H), 4.81 (s, 2H), 2.10 (broad, 1H)

(iv) 4-Cyano-2,6-difluorobenzyl methanesulfonate

To an ice cooled solution of 2,6-difluoro-4-hydroxymethylbenzonitrile (1.24 g, 7.32 mmol; see step (iii) above) and methanesulfonyl chloride (0.93 g, 8.1 mmol) in 60 mL of methylene chloride was added triethylamine (0.81 g, 8.1 mmol) with stirring. After 3 h at 0°C, the mixture was washed twice with 1M HCl and once with water, dried (Na_2SO_4) and evaporated. The product could be used without further purification. Yield: 1.61 g (89%).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.29 (m, 2H), 5.33 (s, 2H), 3.07 (s, 3H)

(v) 4-Azidomethyl-2,6-difluorobenzonitrile

A mixture of 4-cyano-2,6-difluorobenzyl methanesulfonate (1.61 g, 6.51 mmol; see step (iv) above) and sodium azide (0.72 g, 0.0111 mol) in 10 mL of water and 20 mL of DMF was stirred at room temperature overnight. The resultant was subsequently poured into 200 mL of water and extracted three times with diethyl ether. The combined ethereal phase was washed

five times with water, dried (Na_2SO_4) and evaporated. A small sample was evaporated for NMR purposes and the product crystallised. The rest was evaporated cautiously but not until complete dryness. Yield (theoretically 1.26 g) was assumed to be almost quantitative based on NMR and analytical HPLC.

^1H NMR (400 MHz, $CDCl_3$) δ 7.29 (m, 2H), 4.46 (s, 2H)

(vi) 4-Aminomethyl-2,6-difluorobenzonitrile

This reaction was carried out according to the procedure described in *J. Chem. Res. (M)* (1992) 3128. To a suspension of 520 mg of 10% Pd/C (50% moisture) in 20 mL of water was added a solution of sodium borohydride (0.834 g, 0.0221 mol) in 20 mL of water. Some gas evolution resulted. 4-Azidomethyl-2,6-difluorobenzonitrile (1.26 g, 6.49 mmol; see step (v) above) was dissolved in 50 mL of THF and added to the aqueous mixture on an ice bath over 15 min. The mixture was stirred for 4 h, whereafter 20 mL of 2M HCl was added and the mixture was filtered through Celite. The Celite was rinsed with more water and the combined aqueous phase was washed with EtOAc and subsequently made alkaline with 2M NaOH. Extraction three times with methylene chloride followed and the combined organic phase was washed with water, dried (Na_2SO_4) and evaporated. Yield: 0.87 g (80%).

^1H NMR (400 MHz, $CDCl_3$) δ 7.20 (m, 2H), 3.96 (s, 2H), 1.51 (broad, 2H)

(vii) 2,6-Difluoro-4-*tert*-butoxycarbonylaminomethylbenzonitrile

A solution of 4-aminomethyl-2,6-difluorobenzonitrile (0.876 g, 5.21 mmol; see step (vi) above) was dissolved in 50 mL of THF and di-*tert*-butyl dicarbonate (1.14 g , 5.22 mmol) in 10 mL of THF was added. The mixture

was stirred for 3.5 h. The THF was evaporated and the residue was partitioned between water and EtOAc. The organic layer was washed three times with 0.5 M HCl and water, dried (Na_2SO_4) and evaporated. The product could be used without further purification. Yield: 1.38 g (99%).

^1H NMR (300 MHz, $CDCl_3$) δ 7.21 (m,2H), 4.95 (broad, 1H), 4.43 (broad, 2H), 1.52 (s, 9H)

(viii) Boc-Pab(2,6-diF)(OH)

A mixture of 2,6-difluoro-4-*tert*-butoxycarbonylaminomethylbenzonitrile (1.38 g, 5.16 mmol; see step (vii) above), hydroxylamine hydrochloride (1.08 g, 0.0155 mol) and triethylamine (1.57 g, 0.0155 mol) in 20 mL of ethanol was stirred at room temperature for 36 h. The solvent was evaporated and the residue was partitioned between water and methylene chloride. The organic layer was washed with water, dried (Na_2SO_4) and evaporated. The product could be used without further purification. Yield: 1.43 g (92%).

^1H NMR (500 MHz, CD_3OD) δ 7.14 (m, 2H), 4.97 (broad, 1H), 4.84 (broad, 2H), 4.40 (broad, 2H), 1.43 (s, 9H)

(ix) Boc-Pab(2,6-diF) x HOAc

This reaction was carried out according to the procedure described by Judkins *et al*, *Synth. Comm.* (1998) 4351. Boc-Pab(2,6-diF)(OH) (1.32 g, 4.37 mmol; see step (viii) above), acetic anhydride (0.477 g, 4.68 mmol) and 442 mg of 10% Pd/C (50% moisture) in 100 mL of acetic acid was hydrogenated at 5 atm pressure for 3.5 h. The mixture was filtered through Celite, rinsed with ethanol and evaporated. The residue was freeze-dried

from acetonitrile and water and a few drops of ethanol. The sub-title product could be used without further purification. Yield: 1.49 g (99%).

^{1}H NMR (400 MHz, CD_3OD) δ 7.45 (m, 2H), 4.34 (s, 2H), 1.90 (s, 3H), 1.40 (s, 9H)

(x) Boc-Pab(2,6-diF)(Teoc)

To a solution of Boc-Pab(2,6-diF) x HOAc (1.56 g, 5.49 mmol; see step (ix) above) in 100 mL of THF and 1 mL of water was added 2-(trimethylsilyl)ethyl p-nitrophenyl carbonate (1.67 g, 5.89 mmol). A solution of potassium carbonate (1.57 g, 0.0114 mol) in 20 mL of water was added dropwise over 5 min. The mixture was stirred overnight. The THF was evaporated and the residue was partitioned between water and methylene chloride. The aqueous layer was extracted with methylene chloride and the combined organic phase was washed twice with aqueous sodium bicarbonate, dried (Na_2SO_4) and evaporated. Flash chromatography on silica gel with heptane/EtOAc = 2/1 gave 1.71 g (73%) of pure compound.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (m, 2H), 4.97 (broad, 1H), 4.41 (broad, 2H), 4.24 (m, 2H), 1.41 (s, 9H), 1.11 (m, 2H), 0.06 (s, 9H)

(xi) Boc-Aze-Pab(2,6-diF)(Teoc)

Boc-Pab(2,6-diF)(Teoc) (1.009 g, 2.35 mmol; see step (x) above) was dissolved in 50 mL of EtOAc saturated with HCl(g). The mixture was left for 10 min., evaporated and dissolved in 18 mL of DMF, and then cooled on an ice bath. Boc-Aze-OH (0.450 g, 2.24 mmol), PyBOP (1.24 g, 2.35 mmol) and lastly diisopropylethyl amine (1.158 g, 8.96 mmol) were added. The reaction mixture was stirred for 2 h and then poured into 350 mL of

water and extracted three times with EtOAc. The combined organic phase was washed with brine, dried (Na_2SO_4) and evaporated. Flash chromatography on silica gel with heptane:EtOAc (1:3) gave 1.097 g (96%) of the desired compound.

^1H NMR (500 MHz, $CDCl_3$) δ 7.46 (m, 2H), 4.65-4.5 (m, 3H), 4.23 (m, 2H), 3.87 (m, 1H), 3.74 (m, 1H), 2.45-2.3 (m, 2H), 1.40 (s, 9H), 1.10 (m, 2H), 0.05 (s, 9H)

(xii) Ph(3-Cl)(5-$OCHF_2$)-*(R)*CH(OH)C(O)-Aze-Pab(2,6-diF)(Teoc)

Boc-Aze-Pab(2,6-diF)(Teoc) (0.256 g, 0.500 mmol; see step (xi) above) was dissolved in 20 mL of EtOAc saturated with HCl(g). The mixture was left for 10 min. and evaporated and dissolved in 5 mL of DMF. Ph(3-Cl)(5-$OCHF_2$)-*(R)*CH(OH)C(O)OH (0.120 g, 0.475 mmol; see Preparation A(viii) above), PyBOP (0.263 g, 0.498 mmol) and lastly diisopropylethyl amine (0.245 g, 1.89 mmol) were added. The reaction mixture was stirred for 2 h and then poured into 350 mL of water and extracted three times with EtOAc. The combined organic phase was washed with brine, dried (Na_2SO_4) and evaporated. Flash chromatography on silica gel with EtOAc gave 0.184 g (60%) of the desired sub-title compound.

^1H NMR (400 MHz, CD_3OD, mixture of rotamers) δ 7.55-7.45 (m, 2H), 7.32 (m, 1H, major rotamer), 7.27 (m, 1H, minor rotamer), 7.2-7.1 (m, 2H), 6.90 (t, 1H, major rotamer), 6.86 (t, 1H, minor rotamer), 5.15 (s, 1H, major rotamer), 5.12 (m, 1H, minor rotamer), 5.06 (s, 1H, minor rotamer), 4.72 (m, 1H, major rotamer), 4.6-4.45 (m, 2H), 4.30 (m, 1H, major rotamer), 4.24 (m, 2H), 4.13 (m, 1H, major rotamer), 4.04 (m, 1H, minor rotamer), 3.95 (m, 1H, minor rotamer), 2.62 (m, 1H, minor rotamer), 2.48 (m, 1H, major

rotamer), 2.22 (m, 1H, major rotamer), 2.10 (m, 1H, minor rotamer), 1.07 (m, 2H), 0.07 (m, 9H)

(xiii) Ph(3-Cl)(5-$OCHF_2$)-*(R)*CH(OH)C(O)-Aze-Pab(2,6-diF)(OMe,Teoc)

A mixture of Ph(3-Cl)(5-$OCHF_2$)-*(R)*CH(OH)C(O)-Aze-Pab(2,6-diF)(Teoc) (64 mg, 0.099 mmol; see step (xii) above) and O-methyl hydroxylamine hydrochloride (50 mg, 0.60 mmol) in 4 mL of acetonitrile was heated at 70°C for 3 h. The solvent was evaporated and the residue was partitioned between water and EtOAc. The aqueous layer was extracted twice with EtOAc and the combined organic phase was washed with water, dried (Na_2SO_4) and evaporated. The product could be used without further purification. Yield: 58 mg (87%).

^1H NMR (400 MHz, $CDCl_3$) δ 7.90 (bt, 1H), 7.46 (m, 1H), 7.25-6.95 (m, 5H), 6.51, t, 1H), 4.88 (s, 1H), 4.83 (m, 1H), 4.6-4.5 (m, 2H), 4.4-3.9 (m, 4H), 3.95 (s, 3H), 3.63 (m, 1H), 2.67 (m, 1H), 2.38 (m, 1H), 1.87 (broad, 1H), 0.98 (m, 2H), 0.01, s, 9H)

(xiv) Compound B

Ph(3-Cl)(5-$OCHF_2$)-*(R)*CH(OH)C(O)-Aze-Pab(2,6-diF)(OMe,Teoc) (58 mg, 0.086 mmol; see step (xiii) above) was dissolved in 3 mL of TFA, cooled on an ice bath and allowed to react for 2 h. The TFA was evaporated and the residue dissolved in EtOAc. The organic layer was washed twice with aqueous sodium carbonate and water, dried (Na_2SO_4) and evaporated. The residue was freeze-dried from water and acetonitrile to give 42 mg (92%) of the title compound.

^1H NMR (300 MHz, $CDCl_3$) δ 7.95 (bt, 1H), 7.2-7.1 (m, 4H), 6.99 (m, 1H), 6.52 (t, 1H), 4.88 (s, 1H), 4.85-4.75 (m, 3H), 4.6-4.45 (m, 2H), 4.29 (broad,

1H), 4.09 (m, 1H), 3.89 (s, 3H), 3.69 (m, 1H), 2.64 (m, 1H), 2.38 (m, 1H), 1.85 (broad, 1H)

^{13}C-NMR (100 MHz; $CDCl_3$): (carbonyl and/or amidine carbons) δ 172.1, 169.8, 151.9

APCI-MS: (M + 1) = 533/535 m/z

Preparation C

Preparation of Compound C

(i) (2-Monofluoroethyl) methanesulfonate

To a magnetically stirred solution of 2-fluoroethanol (5.0 g, 78.0 mmol) in CH_2Cl_2 (90 mL) under nitrogen at 0°C was added triethylamine (23.7 g, 234 mmol) and methanesulfonyl chloride (10.7 g, 93.7 mmol). The mixture was stirred at 0°C for 1.5 h, diluted with CH_2Cl_2 (100 mL) and washed with 2N HCl (100 mL). The aqueous layer was extracted with CH_2Cl_2 (50 mL) and the combined organic extracts washed with brine (75 mL), dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford the sub-title compound (9.7 g, 88%) as a yellow oil which was used without further purification.

^{1}H NMR (300 MHz, $CDCl_3$) δ 4.76 (t, J = 4 Hz, 1H), 4.64 (t, J = 4 Hz, 1H), 4.52 (t, J = 4 Hz, 1H), 4.43 (t, J = 4 Hz, 1H), 3.09 (s, 3H).

(ii) 3-Chloro-5-monofluoroethoxybenzaldehyde

To a solution of 3-chloro-5-hydroxybenzaldehyde (8.2 g, 52.5 mmol; see Preparation A(ii) above) and potassium carbonate (9.4 g, 68.2 mmol) in DMF (10 mL) under nitrogen was added a solution of (2-monofluoroethyl) methanesulfonate (9.7 g, 68.2 mmol; see step (i) above) in DMF (120 mL) dropwise at room temperature. The mixture was heated to 100°C for 5 h

and then stirred overnight at room temperature. The reaction was cooled to 0°C, poured into ice-cold 2N HCl and extracted with EtOAc. The combined organic extracts were washed with brine, dried (Na_2SO_4), filtered and concentrated *in vacuo*. The brown oil was chromatographed on silica gel eluting with Hex:EtOAc (4:1) to afford the sub-title compound (7.6 g, 71%) as a yellow oil.

^1H NMR (300 MHz, $CDCl_3$) δ 9.92 (s, 1H), 7.48 (s, 1H), 7.32 (s, 1H), 7.21 (s, 1H), 4.87 (t, J = 4 Hz, 1H), 4.71 (t, J = 3 Hz, 1H), 4.33 (t, J = 3 Hz, 1H), 4.24 (t, J = 3 Hz, 1H).

(iii) Ph(3-Cl)(5-OCH_2CH_2F)-(*R*,*S*)CH(OTMS)CN

To a solution of 3-chloro-5-monofluoroethoxybenzaldehyde (7.6 g, 37.5 mmol; see step (ii) above) and zinc iodide (3.0 g, 9.38 mmol) in CH_2Cl_2 (310 mL) was added trimethylsilyl cyanide (7.4 g, 75.0 mmol) dropwise at 0°C under nitrogen. The mixture was stirred at 0°C for 3 h and at room temperature overnight. The reaction was diluted with H_2O (300 mL), the organic layer was separated, dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford the sub-title compound (10.6 g, 94%) as a brown oil that was used without further purification or characterisation.

(iv) Ph(3-Cl)(5-OCH_2CH_2F)-(*R*,*S*)CH(OH)C(O)OH

Concentrated hydrochloric acid (100 mL) was added to Ph(3-Cl)(5-OCH_2CH_2F)-(*R*,*S*)CH(OTMS)CN (10.6 g, 5.8 mmol; see step (iii) above) and the solution stirred at 100°C for 3 h. After cooling to room temperature, the reaction was further cooled to 0°C, basified slowly with 3N NaOH (~300 mL) and washed with Et_2O (3 x 200 mL). The aqueous layer was acidified with 2N HCl (80 mL) and extracted with EtOAc (3 x 300 mL). The combined EtOAc extracts were dried (Na_2SO_4), filtered and

concentrated *in vacuo* to afford the sub-title compound (8.6 g, 98%) as a pale yellow solid that was used without further purification.

R_f = 0.28 (90:8:2 $CHCl_3$:MeOH:concentrated NH_4OH)

^1H NMR (300 MHz, CD_3OD) δ 7.09 (s, 1H), 7.02 (s, 1H), 6.93 (s, 1H), 5.11 (s, 1H), 4.77-4.81 (m, 1H), 4.62-4.65 (m, 1H), 4.25-4.28 (m, 1H), 4.15-4.18 (m, 1H).

(v) Ph(3-Cl)(5-OCH_2CH_2F)-(*S*)CH(OAc)C(O)OH (a) and Ph(3-Cl)(5-OCH_2CH_2F)-(*R*)CH(OH)C(O)OH (b)

A solution of Ph(3-Cl)(5-OCH_2CH_2F)-(*R,S*)CH(OH)C(O)OH (8.6 g, 34.5 mmol; see step (iv) above) and Lipase PS "Amano" (4.0 g) in vinyl acetate (250 mL) and MTBE (250 mL) was heated at 70°C under nitrogen for 3 d. The reaction was cooled to room temperature and the enzyme removed by filtration through Celite®. The filter cake was washed with EtOAc and the filtrate concentrated *in vacuo*. Chromatography on silica gel eluting with $CHCl_3$:MeOH:Et_3N (90:8:2) afforded the triethylamine salt of sub-title compound (a) as a yellow oil. In addition, the triethylamine salt of sub-title compound (b) (4.0 g) was obtained. The salt of sub-title compound (b) was dissolved in H_2O (250 mL), acidified with 2N HCl and extracted with EtOAc (3 x 200 mL). The combined organic extracts were dried (Na_2SO_4), filtered and concentrated *in vacuo* to yield the sub-title compound (b) (2.8 g, 32%) as a yellow oil.

Data for Sub-Title Compound (b):

R_f = 0.28 (90:8:2 $CHCl_3$:MeOH:concentrated NH_4OH)

^1H NMR (300 MHz, CD_3OD) δ 7.09 (s, 1H), 7.02 (s, 1H), 6.93 (s, 1H), 5.11 (s, 1H), 4.77-4.81 (m, 1H), 4.62-4.65 (m, 1H), 4.25-4.28 (m, 1H), 4.15-4.18 (m, 1H).

(vi) Compound C

To a solution of Ph(3-Cl)(5-OCH_2CH_2F)-(*R*)CH(OH)C(O)OH (818 mg, 3.29 mmol; see step (v) above) in DMF (30 mL) under nitrogen at 0°C was added HAze-Pab(OMe)•2HCl (1.43 g, 4.27 mmol, see international patent application WO 00/42059), PyBOP (1.89 g, 3.68 mmol), and DIPEA (1.06 g, 8.23 mmol). The reaction was stirred at 0°C for 2 h and then at room temperature overnight. The mixture was concentrated *in vacuo* and the residue chromatographed two times on silica gel, eluting first with $CHCl_3$:EtOH (15:1) and second with EtOAc:EtOH (20:1) to afford the title compound (880 mg, 54%).

R_f = 0.60 (10:1 $CHCl_3$:EtOH)

^1H NMR (300 MHz, CD_3OD, complex mixture of rotamers) δ 7.58-7.60 (d, *J* = 8 Hz, 2H), 7.34 (d, *J* = 7 Hz, 2H), 7.05-7.08 (m, 2H), 6.95-6.99 (m, 1H), 5.08-5.13 (m, 1H), 4.77-4.82 (m, 1H), 4.60-4.68 (m, 1H), 3.99-4.51 (m, 7H), 3.82 (s, 3H), 2.10-2.75 (m, 2H).

^{13}C-NMR (150 MHz; CD_3OD): (carbonyl and/or amidine carbons) δ 173.3, 170.8, 152.5.

APCI-MS: (M + 1) = 493 m/z.

Examples 1 and 2

Preparation of Salts of Compound A

Example 1

General Method for Salt Preparation

The following generic method was employed to prepare salts of Compound A: 200 mg of Compound A (see Preparation A above) was dissolved in 5 mL of MeOH. To this solution was added a solution of the relevant acid

(1.0 molar equivalent) dissolved in 5 mL of MeOH. After stirring for 10 minutes at room temperature, the solvent was removed by way of a rotary evaporator. The remaining solid material was re-dissolved in 8 mL of acetonitrile:H_2O (1:1). Freeze-drying afforded colorless amorphous material in each case.

Acids employed:

(1S)-(+)-10-camphorsulfonic

malic

cyclohexylsulphamic

phosphoric

dimethylphosphoric

p-toluenesulphonic

L-lysine

L-lysine hydrochloride

saccharinic

methanesulphonic

hydrochloric

Appropriate characterising data are shown in Table 1.

Table 1

Salt	Mw acid	Mw salt	LRMS	δ ppm (MeOD) H18, H19, H24 (see structure at end of Example 9 below)
(1*S*)-(+)-10-	232.20	729.20	230.9	7.57, 7.68, 3.97

camphorsulfonic acid			495.1 497.0 727.3	
maleate	116.07	612.97	114.8 495.1 497.0	7.45, 7.64, 3.89
cyclohexylsulphamate	179.24	676.14	177.9 495.1 496.9 674.3 676.1	7.44, 7.64, 3.89
phosphate	97.99	594.89	495.1 497.0 593.1	7.37, 7.61, 3.84
dimethylphosphate	126.05	622.95	124.9 495.1 497.0 621.2 623.0	7.50, 7.66, 3.92
p-toluenesulphonate	172.20	669.10	170.9 495.1 497.0	7.54, 7.71, 3.95
L-lysine	146.19	643.09	145.0 495.1 497.0	7.36, 7.60, 3.83
L-lysine hydrochloride	182.65	679.55	495.1 497.0 531.1 (HCl)	7.36, 7.60, 3.83

saccharinate	183.19	680.09	181.9 495.1 497.0	7.44, 7.64. 3.89
methanesulphonate	96.11	593.01	495.1 497.0 591.2 593.1	7.57, 7.68, 3.97
hydrochloride	36.46	533.36	495.1 496.9 531.1 532.5 535.2	7.55, 7.67, 3.95

All salts formed in this Example were amorphous.

Example 2

Further amorphous salts of Compound A were made using analogous techniques to those described in Example 1 above from the following acids:

hydrobromic acid (1:1 salt)

hydrochloric acid (1:1 salt)

sulphuric acid (1:0.5 salt)

1,2-ethanedisulfonic acid (1.0.5 salt)

1S-camphorsulfonic acid (1:1 salt)

(+/-)-camphorsulfonic acid (1:1 salt)

ethanesulfonic acid (1:1 salt)

nitric acid (1:1 salt)

toluenesulfonic acid (1:1 salt)

methanesulfonic acid (1:1 salt)

p-xylenesulfonic acid (1:1 salt)

2-mesitylenesulfonic acid (1:1 salt)

1,5-naphthalenesulfonic acid (1:0.5 salt)

naphthalenesulfonic acid (1:1 salt)

benzenesulfonic acid (1:1 salt)

saccharinic acid (1:1 salt)

maleic acid (1:1 salt)

phosphoric acid (1:1 salt)

D-glutamic acid (1:1 salt)

L-glutamic acid (1:1 salt)

D,L-glutamic acid (1:1 salt)

L-arginine (1:1 salt)

L-lysine (1:1 salt)

L-lysine hydrochloride (1:1 salt)

glycine (1:1 salt)

salicylic acid (1:1 salt)

tartaric acid (1:1 salt)

fumaric acid (1:1 salt)

citric acid (1:1 salt)

L-(-)-malic acid (1:1 salt)

D,L-malic acid (1:1 salt)

D-gluconic acid (1:1 salt)

Example 3

Preparation of Amorphous Compound A, ethanesulfonic acid salt

Compound A (203 mg; see Preparation A above) was dissolved in ethanol (3 mL) and ethanesulfonic acid (1 eq., 95%, 35 µL) was added to the solution. The mixture was stirred for a few minutes, and then the solvent was evaporated. The resulting oil was slurried in *iso*-octane and evaporated to dryness until a solid material was obtained. Finally, the substance was re-

slurried in *iso*-octane and the solvent evaporated again resulting in a white, dry, amorphous solid. The substance was vacuum dried at 40°C overnight.

Examples 4 to 9

Preparation of Crystalline Compound A, ethanesulfonic acid salt

Example 4

Crystallisation of Amorphous Material

Amorphous Compound A, ethanesulfonic acid salt (17.8 mg; see Example 3 above) was slurried in methyl *iso*-butyl ketone (600 µL). After 1 week, crystalline needles were observed, which were filtered off and air-dried.

Examples 5 to 7

Reaction Crystallisations (without Anti-solvent)

Example 5

Compound A (277 mg; see Preparation A above) was dissolved in methyl *iso*-butyl ketone (3.1 mL). Ethanesulfonic acid was added (1 eq., 95%, 48 µL). Precipitation of amorphous ethanesulfonate salt occurred immediately. More methyl *iso*-butyl ketone (6 mL) was added and the slurry was treated with ultrasound. Finally, a third portion of methyl *iso*-butyl ketone (3.6 mL) was added and then the slurry was left overnight with stirring (magnetic stirrer). The next day, the substance had transformed into crystalline needles. The slurry was filtered off, washed with methyl *iso*-butyl ketone (0.5 mL) and air dried.

Example 6

Compound A (236 mg; see Preparation A above) was dissolved at room temperature in methyl *iso*-butyl ketone (7 mL). Ethanesulfonic acid (1 eq.,

41μL) was mixed with 2 mL of methyl *iso*-butyl ketone in a vial. The solution of Compound A was seeded with crystalline Compound A, ethanesulfonic acid salt (see Examples 4 and 5 above). Then, 250 μL of the methyl *iso*-butyl ketone solution of ethanesulfonic acid was added in portions over 45 minutes. The solution was seeded again, and the temperature was increased to 30°C. Then, 500 μL of the methyl *iso*-butyl ketone solution was added over approximately 1 hour. The resulting slurry was left overnight before a final amount of the methyl *iso*-butyl ketone/acid solution was added over 20 minutes. The vial was rinsed with 1.5 mL of methyl *iso*-butyl ketone, which was added to the slurry. After a further 6 hours, the crystals were filtered off, washed with methyl *iso*-butyl ketone (2 mL) and dried under reduced pressure at 40°C. A total of 258 mg of crystalline salt was obtained which corresponds to a yield of approximately 87%.

Example 7

Compound A (2.36 g; see Preparation A above) was dissolved in methyl *iso*-butyl ketone (90 mL). Seed crystals (10 mg) of Compound A, ethanesulfonic acid salt (see Examples 4 to 6 above) were added to the solution, and then ethanesulfonic acid (40 μL) was added in two portions. Further seed crystals (12 mg) and two portions of ethanesulfonic acid (2 x 20 μL) were then added. The slurry was diluted with methyl *iso*-butyl ketone (15 mL) before the addition of ethanesulfonic acid was continued. A total amount of 330 μL ethanesulfonic acid was added, in portions, over 1 hour. A small amount of seed crystals was added and, finally, the slurry was left overnight with stirring. The next day, the crystals were filtered off, washed with methyl *iso*-butyl ketone (2 x 6 mL) and dried under reduced pressure at 40°C. After drying, a total of 2.57 g of white, crystalline product was obtained corresponding to a yield of 89%.

Examples 8 and 9

Reaction Crystallizations (with Anti-solvent)

Example 8

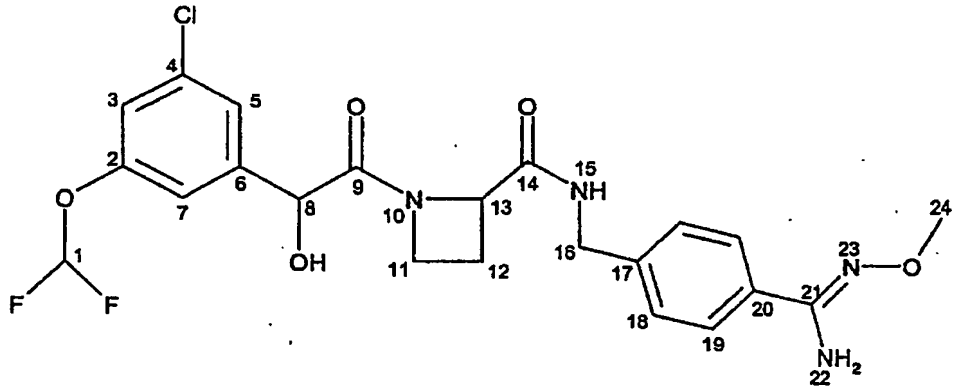
Compound A (163 mg; see Preparation A above) was dissolved in *iso*-propanol (1.2 mL). The solution was heated to 35°C. Ethanesulfonic acid was added (28 µL). Then, ethyl acetate (4.8 mL) was added and the solution was seeded with crystalline Compound A, ethanesulphonic acid salt (see Examples 4 to 7 above). Crystallization started almost immediately. The slurry was left for about 80 minutes at 35°C before being allowed to cool to ambient temperature (21°C). Two hours later, the crystals were filtered off, washed three times with ethyl acetate (3 x 0.4 mL), and dried under reduced pressure at 40°C. A total of 170 mg of crystalline title product was obtained which corresponds to a yield of approximately 82%.

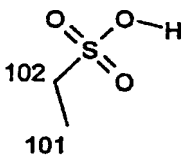
Example 9

Compound A (20.0 g; see Preparation A above) was dissolved in *iso*-propanol (146.6 mL) at 40°C and ethanesulfonic acid (3.46 mL, 95%, 1 eq.) was added to the solution. To the resulting clear solution, seed crystals of Compound A, ethanesulfonic acid salt were added (50 mg; see Examples 4 to 8 above). Then, ethyl acetate (234 mL) was added over 10 minutes. The resulting slightly opaque solution was seeded once more (70 mg) and left for one hour at 40°C with stirring to allow for crystallization to start. After this, a total of 352 mL of ethyl acetate was added at a constant rate over one hour. When all of the ethyl acetate had been added, the slurry was left for 1 hour, before being cooled to 21°C over 2 hours. The crystallization was allowed to continue for 1 hour at 21°C before the crystals were filtered off,

washed twice with ethyl acetate (50 mL + 60 mL) and finally, dried under reduced pressure at 40°C overnight. A total of 21.6 g of a white, crystalline salt was obtained, corresponding to a yield of approximately 90%.

Compound A, ethanesulfonic acid salt was characterised by NMR as follows: 23 mg of the salt was dissolved in deuterated methanol (0.7 mL) troscopy. A combination of 1D (^{1}H, ^{13}C and selective NOE) and 2D (gCOSY, gHSQC and gHMBC) NMR experiments were used. All data were in good agreement with the theoretical structure of the salt, shown below. The molecule exists in two conformations in methanol. Based on the integral of the peak assigned to H5 (dominant conformer) and peak assigned to H5' (other conformer), the ratio between the two conformers was found to be 70:30. H22 could not be observed as these protons were in fast exchange with the solvent CD_3OD.





Both the proton and the carbon resonance corresponding to position 1 are split due to the spin-coupling with the two fluorine nuclei in that position. The coupling constants are $^2J_{HF}$=73 Hz and $^1J_{CF}$= 263 Hz.

^1H and ^{13}C NMR chemical shift assignment and proton-proton correlations are shown in Table 2

Table 2

Atom No.	Type	^{13}C shift/ ppm[a]	^1H shift/ppm[b] and multiplicity[c]	J_{HH}/Hz
1	CH	117.5[e]	6.90 (t)	73 ($^2J_{HF}$)
1'		117.5[e]	6.88 (t)	
2	C	153.5		
2'		153.5		
3	CH	120.0	7.15 (s)	
3'		119.7	7.13 (s)	
4	C	136.2		
4'		135.9		
5	CH	125.0	7.36 (s)	
5'		124.9	7.31 (s)	
6	C	144.5		
6'		145.3		
7	CH	117.3	7.20 (s)	
7'		117.2	7.15 (s)	
8	CH	72.0	5.20 (s)	
8'		74.0	5.12 (s)	
9	CO	173.1		
9'		173.8		

11	CH_2	51.6	a:4.38 (m)	
			b:4.21 (m)	
11'		49.0	a:4.06 (m)	
			b:3.99 (m)	
12	CH_2	21.7	a:2.55 (m)	
			b:2.29 (m)	
12'		23.2	a:2.70 (m)	
			b:2.15 (m)	
13	CH	63.1	4.80 (m)	
13'		66.2	5.22 (m)	
14	CO	172.9		
14'		173.6		
15	NH		8.76 (t, br)	5.2
15'			8.79 (t, br)	5.2
16	CH_2	43.5	4.59 (AB-pattern)	15.9
			4.46 (AB-pattern)	15.9
16'		43.6	4.53 (AB-pattern)	15.9
			4.49 (AB-pattern)	15.9
17	C	146.9		
17'		147.0		
18	CH	129.1	7.56 (d)	7.8
18'		129.1	7.57 (d)	7.8
19	CH	129.2	7.67 (d)	7.8
19'		129.4	7.70 (d)	7.8
20	C	124.9		
20'		124.9		
21	C	162.4		
21'		162.3		

22	NH_2		Not observed	
24	CH_3	64.8	3.96 (s)	
101	CH3		1.28 (t)	7.4
102	CH2		2.77 (m)	7.4

[a]Relative to the solvent resonance at 49.0 ppm.

[b]Relative to the solvent resonance at 3.30 ppm.

[c]s=singlet, t=triplet, m=multiplet, br=broad, d=doublet

[d]Obtained in the gCOSY experiment.

[e]The resonance is a triplet due to coupling with the two fluorine nuclei. $^1J_{CF}$=263 Hz.

HRMS calculated for $C_{24}H_{29}ClF_2N_4O_8S$ $(M-H)^-$ 605.1284, found 605.1296.

Crystals of Compound A, ethanesulfonic acid salt (obtained by way of one or more of Examples 4 to 9 above) were analyzed by XRPD and the results are tabulated below (Table 3) and are shown in Figure 1.

Table 3

d value (Å)	Intensity (%)
16.5	10
12.2	74
11.0	4
9.0	33
8.3	3
7.6	6

6.4	4
6.2	12
6.0	7
5.9	10
5.5	15
5.4	100
5.1	7
4.66	29
4.60	36
4.31	57
4.25	18
4.19	20
4.13	12
4.00	12
3.87	13
3.83	6
3.76	7
3.72	6
3.57	9
3.51	7
3.47	5
3.39	3
3.31	11
3.26	10
3.21	8
3.16	4
3.03	8
2.78	4

2.74	5
2.67	3
2.56	5
2.50	5
2.46	7
2.34	4
2.21	5
2.00	3
1.98	3

DSC showed an endotherm with an extrapolated melting onset temperature of *ca.* 131°C. TGA showed a decrease in mass of *ca.* 0.2% (w/w) around the melting point.

Example 10

Preparation of Amorphous Compound A, benzenesulfonic acid salt

Compound A (199 mg; see Preparation A above) was dissolved in ethanol (2 mL). Benzenesulfonic acid (1 eq. 90%, 70mg) was dissolved in ethanol (1 mL) in a vial. The ethanol solution of the acid was added to the solution of Compound A and the vial was rinsed with 1 mL ethanol, which was then added to the mixture. The mixture was stirred for a few minutes, and then the ethanol was evaporated until an oil was formed. Ethyl acetate (3 mL) was added and the solvent was evaporated again to dryness. An amorphous solid was formed.

Examples 11 to 13

Preparation of Crystalline Compound A, benzenesulfonic acid salt

Example 11

Crystallisation of Amorphous Material

Amorphous Compound A benzenesulfonic acid salt (20.7 mg; see Example 10 above) was slurried in ethyl acetate (600 µL). After 5 days, crystalline needles were observed in the slurry.

Examples 12 and 13

Reaction Crystallisations

Example 12

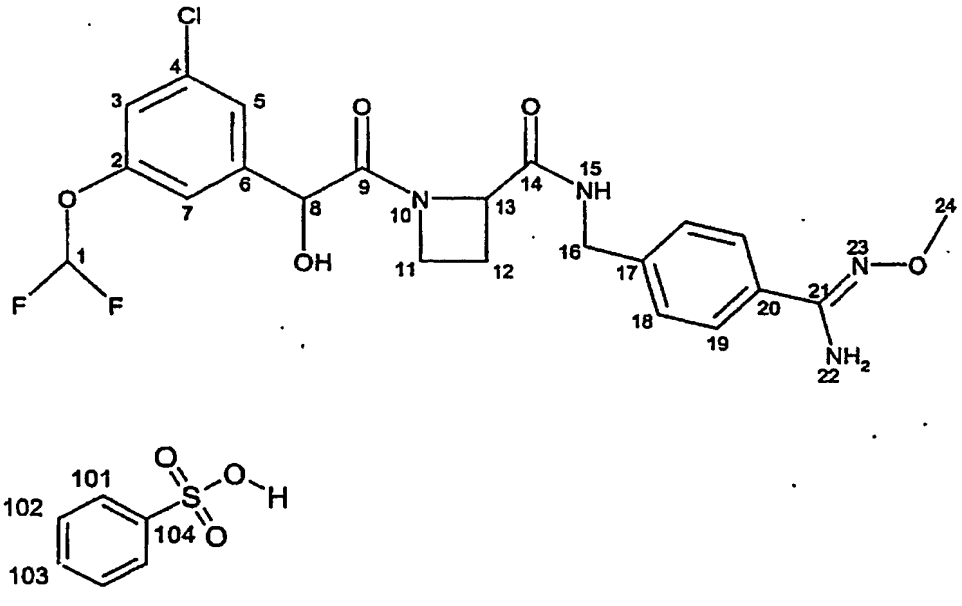
Compound A (128 mg; see Preparation A above) was dissolved in ethyl acetate (3 mL). The solution was seeded with the slurry from Example 11 above. Then, benzenesulfonic acid was added (1 eq., 90%, 45 mg). Precipitation of benzenesulphonic acid salt occurred immediately. *iso*-Propanol was added to the slurry (0.8 mL) and the mixture was seeded again. Two days later, the substance had transformed into crystalline needles. The slurry was filtered off, washed with ethyl acetate (3 x 0.2 mL) and dried for a short time under vacuum at 40°C. A total of approximately 140 mg of white solid was obtained.

Example 13

Compound A (246 mg; see Preparation A above) was dissolved in *iso*-propanol (1.52 mL). Benzenesulfonic acid was added (88 mg, 90%). To the clear solution, ethyl acetate was added (3 mL), and then the mixture was seeded to initiate crystallisation. After 1 hour, more ethyl acetate was added (2.77 mL). Finally, the slurry was allowed to crystallise overnight before

the crystals were filtered off, washed with ethyl acetate (3 x 0.3 mL) and dried at 40°C under vacuum. A total of 279 mg salt was obtained which corresponds to a yield of approximately 86%.

Compound A, benzenesulfonic acid salt was characterised by NMR as follows: 20 mg of the salt was dissolved in deuterated methanol (0.7 mL). A combination of 1D (^{1}H, ^{13}C and selective NOE) and 2D (gCOSY, gHSQC and gHMBC) NMR experiments were used. All data were in good agreement with the theoretical structure of the salt, shown below. The molecule exists in two conformations in methanol. Based on the integral of the peak assigned to H12 (dominant conformer) and peak assigned to H12' (other conformer), the ratio between the two conformers was found to be 70:30. H22 could not be observed as these protons were in fast exchange with the solvent CD_3OD.



Both the proton and the carbon resonance corresponding to position 1 are split due to the spin-coupling with the two fluorine nuclei in that position. The coupling constants are $^2J_{HF}$=74 Hz and $^1J_{CF}$= 260 Hz.

^1H and ^{13}C NMR chemical shift assignment and proton-proton correlations are shown in Table 4.

Table 4

Atom No.	Type	^{13}C shift/ ppm[a]	^1H shift/ppm[b] and multiplicity[c]	J_{HH}/Hz
1	CH	117.5[e]	6.89 (t)	74 ($^2J_{HF}$)
1'		117.5[e]	6.87 (t)	
2	C	153.5		
2'		153.5		
3	CH	120.1	7.15 (s)	
3'		119.7	7.12 (s)	
4	C	136.2		
4'		135.9		
5	CH	125.1	7.35 (s)	
5'		124.9	7.31 (s)	
6	C	144.5		
6'		145.3		
7	CH	117.3	7.20 (s)	
7'		117.2	7.14 (s)	
8	CH	72.8	5.20 (s)	
8'		74.0	5.12 (s)	
9	CO	173.1		
9'		173.8		
11	CH_2	51.6	a:4.37 (m)	
			b:4.20 (m)	

11'		49.0	a:4.05 (m) b:3.98 (m)	
12	CH_2	21.7	a:2.53 (m) b:2.28 (m)	
12'		23.2	a:2.69 (m) b:2.14 (m)	
13	CH	63.1	4.79 (m)	
13'		66.2	5.22 (m)	
14	CO	172.9		
14'		173.6		
15	NH		8.75 (t, br)	5.3
15'			8.78 (t, br)	5.3
16	CH_2	43.5	4.59 (AB-pattern) 4.44 (AB-pattern)	16.0 and 5.2 16.0 and 4.8
16'		43.6	4.51 (AB-pattern) 4.46 (AB-pattern)	16.0 16.0
17	C	146.9		
17'		147.0		
18	CH	129.2	7.54 (d)	8.3
18'		129.2	7.56 (d)	8.3
19	CH	129.3	7.66 (d)	8.3
19'		129.4	7.69 (d)	8.3
20	C	124.9		
20'		124.9		
21	C	162.4		
21'		162.4		
22	NH_2		Not observed	
24	CH_3	64.8	3.95 (s)	
101	CH	126.9	7.81 (m)	
102	CH	129.1	7.41 (m)	

103	CH	131.2	7.42 (m)	
104	C	146.4		

[a]Relative to the solvent resonance at 49.0 ppm.

[b]Relative to the solvent resonance at 3.30 ppm.

[c]s=singlet, t=triplet, m=multiplet, br=broad, d=doublet.

[d]Obtained in the gCOSY experiment.

[e]The resonance is a triplet due to coupling with the two fluorine nuclei. $^1J_{CF}$=260 Hz.

[f]connectivity difficult to determine due to overlap between resonance 102 and 103

HRMS calculated for $C_{28}H_{29}ClF_2N_4O_8S$ $(M-H)^-$ 653.1284, found 653.1312.

Crystals of Compound A, benzenesulfonic acid salt (obtained by way of one or more of Examples 11 to 13 above) were analyzed by XRPD and the results are tabulated below (Table 5) and are shown in Figure 2.

Table 5

d value (Å)	Intensity (%)
14.2	12
12.6	55
10.2	49
7.5	8
6.4	5
6.3	30
6.1	5

5.9	100
5.7	20
5.4	9
5.3	11
5.1	10
4.96	3
4.83	27
4.73	72
4.54	23
4.50	10
4.35	28
4.30	38
4.24	24
4.17	28
4.09	60
4.08	61
3.96	29
3.91	15
3.77	22
3.62	11
3.52	20
3.31	44
3.19	8
3.15	11
3.09	8
3.00	7
2.89	3
2.86	4

2.79	7
2.76	6
2.72	5
2.59	6
2.56	9
2.54	9
2.49	7
2.38	8
2.16	4
2.03	3

DSC showed an endotherm with an extrapolated melting onset temperature of *ca.* 152°C. TGA showed a decrease in mass of *ca.* 0.1% (w/w) around the melting point.

Example 14

Preparation of Amorphous Compound A, *n*-propanesulfonic acid salt

Compound A (186 mg; see Preparation A above) was dissolved in *iso*-propanol (1.39 mL) and *n*-propanesulfonic acid (1 eq., 95%, 39 µL) was added. Ethyl acetate (5.6 mL) was added and the solvent was evaporated until a dry, amorphous solid was formed.

Examples 15 and 16

Preparation of Crystalline Compound A, *n*-propanesulfonic acid salt

Example 15

Crystallisation of Amorphous Material

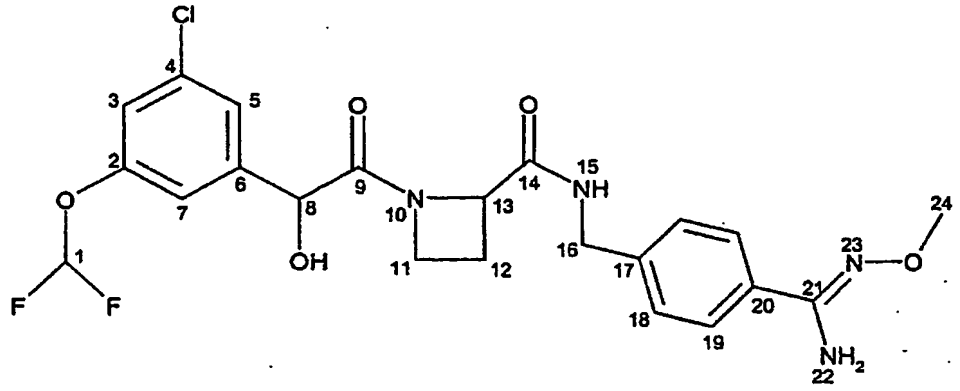
Amorphous Compound A, *n*-propanesulfonic acid salt (20 mg; see Example 14 above) was dissolved in *iso*-propanol (60 µL) and *iso*-propyl acetate (180 µL) was added. After three days crystalline needles were observed.

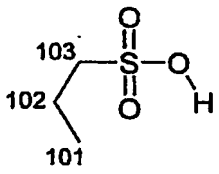
Example 16

Reaction Crystallisation

Compound A (229 mg; see Preparation A above) was dissolved in *iso*-propanol (1.43 mL). *n*-Propanesulfonic acid was added (1 eq., 95%, 48 µL). Ethyl acetate was added (2 mL), and then the solution was seeded with crystalline salt from Example 15 above. Further ethyl acetate was added (5 mL) and the slurry was left overnight to crystallize. The crystals were filtered off, washed with ethyl acetate (3 x 0.3 mL) and dried under vacuum at 40°C.

Compound A, *n*-propanesulfonic acid salt was characterised by NMR as follows: 13 mg of the salt was dissolved in deuterated methanol (0.7 mL) troscopy. A combination of 1D (^{1}H, ^{13}C) and 2D (gCOSY) NMR experiments were used. All data were in good agreement with the theoretical structure of the salt, shown below. The molecule exists in two conformations in methanol. Based on the integral of the peak assigned to H12 (dominant conformer) and peak assigned to H12' (other conformer), the ratio between the two conformers was found to be 65:35. H22 could not be observed as these protons were in fast exchange with the solvent CD_3OD.





Both the proton and the carbon resonance corresponding to position 1 are split due to the spin-coupling with the two fluorine nuclei in that position. The coupling constants are $^{2}J_{HF}$=74 Hz and $^{1}J_{CF}$= 260 Hz.

^{1}H and ^{13}C NMR chemical shift assignment and proton-proton correlations are shown in Table 6.

Table 6

Atom No.	Type	^{13}C shift/ ppm[a]	^{1}H shift/ppm[b] and multiplicity[c]	J_{HH}/Hz
1	CH	117.5[e]	6.89 (t)	74 ($^{2}J_{HF}$)
1'		117.5[e]	6.88 (t)	
2	C	153.5		
2'		153.5		

3	CH	120.0	7.16 (s)	
3'		119.7	7.13 (s)	
4	C	136.2		
4'		135.9		
5	CH	125.1	7.36 (s)	
5'		124.9	7.31 (s)	
6	C	144.5		
6'		145.3		
7	CH	117.3	7.20 (s)	
7'		117.2	7.16 (s)	
8	CH	72.9	5.20 (s)	
8'		74.1	5.12 (s)	
9	CO	173.1		
9'		173.8		
11	CH_2	51.6	a:4.37 (m)	
			b:4.20 (m)	
11'		49.0	a:4.06 (m)	
			b:3.98 (m)	
12	CH_2	21.7	a:2.53 (m)	
			b:2.29 (m)	
12'		23.2	a:2.69 (m)	
			b:2.15 (m)	
13	CH	63.1	4.80 (m)	
13'		66.2	5.22 (m)	
14	CO	172.9		
14'		173.8		
15	NH		8.75 (t, br)	5.5
15'			8.79 (t, br)	5.5

16	CH_2	43.5	4.59 (AB-pattern)	16.0 and 6.6
			4.45 (AB-pattern)	16.0 and 5.3
16'		43.6	4.51	
			4.50	
17	C	146.9		
17'		147.0		
18	CH	129.1	7.54 (d)	8.5
18'		129.2	7.57 (d)	8.5
19	CH	129.2	7.67 (d)	8.5
19'		129.4	7.69 (d)	8.5
20	C	124.9		
20'		124.9		
21	C	162.4		
21'		162.4		
22	NH_2		Not observed	
24	CH_3	64.7	3.96 (s)	
101	CH	13.7	1.0 (t)	
102	CH	19.6	1.78 (m)	
103	CH	54.6	2.75 (m)	

[a]Relative to the solvent resonance at 49.0 ppm.

[b]Relative to the solvent resonance at 3.30 ppm.

[c]s=singlet, t=triplet, m=multiplet, br=broad, d=doublet.

[d]Obtained in the gCOSY experiment.

[e]The resonance is a triplet due to coupling with the two fluorine nuclei. $^1J_{CF}$=260 Hz.

HRMS calculated for $C_{25}H_{31}ClF_2N_4O_8S$ $(M-H)^-$ 619.1441, found 619.1436.

Crystals of Compound A, *n*-propanesulfonic acid salt (obtained by way of one or more of Examples 15 and 16 above) were analyzed by XRPD and the results are tabulated below (Table 7) and are shown in Figure 3.

Table 7

d value (Å)	Intensity (%)
14.0	4
12.4	87
10.0	30
8.0	3
7.5	7
7.0	0.6
6.7	1
6.4	1
6.2	12
6.1	3
5.8	100
5.7	11
5.5	3
5.4	5
5.3	5
5.2	2
5.1	3
4.94	3
4.78	21
4.68	42

4.51	10
4.49	7
4.40	5
4.32	10
4.29	10
4.25	22
4.19	14
4.14	15
4.07	23
4.04	20
3.94	16
3.88	10
3.73	15
3.65	2
3.59	3
3.48	18
3.28	23
3.12	4
3.06	3
2.97	6
2.84	2
2.81	3
2.76	2
2.73	3
2.70	2
2.57	2
2.54	6
2.51	6

2.46	8
2.42	2
2.39	3
2.36	3
2.32	2
2.14	3
2.01	2

DSC showed an endotherm with an extrapolated melting onset temperature of *ca.* 135°C. TGA showed no decrease in mass around the melting point.

Abbreviations

Ac	=	acetyl
APCI	=	atmospheric pressure chemical ionisation (in relation to MS)
API	=	atmospheric pressure ionisation (in relation to MS)
aq.	=	aqueous
Aze(& (*S*)-Aze)	=	(*S*)-azetidine-2-carboxylate (unless otherwise specified)
Boc	=	*tert*-butyloxycarbonyl
br	=	broad (in relation to NMR)
CI	=	chemical ionisation (in relation to MS)
d	=	day(s)
d	=	doublet (in relation to NMR)
DCC	=	dicyclohexyl carbodiimide
dd	=	doublet of doublets (in relation to NMR)
DIBAL-H	=	di-isobutylaluminium hydride

	DIPEA	=	diisopropylethylamine
	DMAP	=	4-(*N*,*N*-dimethyl amino) pyridine
	DMF	=	*N*,*N*-dimethylformamide
	DMSO	=	dimethylsulfoxide
5	DSC	=	differential scanning colorimetry
	DVT	=	deep vein thrombosis
	EDC	=	1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride
	eq.	=	equivalents
10	ES	=	electrospray
	ESI	=	electrospray interface
	Et	=	ethyl
	ether	=	diethyl ether
	EtOAc	=	ethyl acetate
15	EtOH	=	ethanol
	Et_2O	=	diethyl ether
	FT-IR	=	Fourier-transform infra-red spectroscopy
	gCOSY	=	gradient-selective correlated spectroscopy
	gHMBC	=	gradient-selective heteronuclear multiple bond
20			correlation spectroscopy
	gHSQC	=	gradient-selective heteronuclear single quantum coherence
	HATU	=	*O*-(azabenzotriazol-1-yl)-*N*,*N*,*N*',*N*'-tetramethyluronium hexafluorophosphate.
25	HBTU	=	[*N*,*N*,*N*',*N*'-tetramethyl-*O*-(benzotriazol-1-yl)uronium hexafluorophosphate]
	HCl	=	hydrochloric acid, hydrogen chloride gas or hydrochloride salt (depending on context)
	Hex	=	hexanes

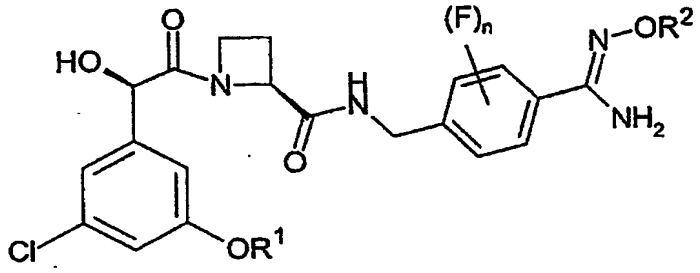
	HOAc	=	acetic acid
	HPLC	=	high performance liquid chromatography
	LC	=	liquid chromatography
	m	=	multiplet (in relation to NMR)
	Me	=	methyl
	MeOH	=	methanol
	min.	=	minute(s)
	MS	=	mass spectroscopy
	MTBE	=	methyl *tert*-butyl ether
	NOE	=	nuclear Overhauser enhancement
	NMR	=	nuclear magnetic resonance
	OAc	=	acetate
	Pab	=	*para*-amidinobenzylamino
	H-Pab	=	*para*-amidinobenzylamine
	Pd/C	=	palladium on carbon
	Ph	=	phenyl
	PyBOP	=	(benzotriazol-1-yloxy)tripyrrolidinophosphonium hexafluorophosphate
	q	=	quartet (in relation to NMR)
	QF	=	tetrabutylammonium fluoride
	rt/RT	=	room temperature
	s	=	singlet (in relation to NMR)
	t	=	triplet (in relation to NMR)
	TBTU	=	[*N,N,N',N'*-tetramethyl-*O*-(benzotriazol-1-yl)uronium tetrafluoroborate]
	TEA	=	triethylamine
	Teoc	=	2-(trimethylsilyl)ethoxycarbonyl
	TEMPO	=	2,2,6,6-tetramethyl-1-piperidinyloxy free radical
	TFA	=	trifluoroacetic acid

TGA	=	thermogravimetric analysis
THF	=	tetrahydrofuran
TLC	=	thin layer chromatography
UV	=	ultraviolet
XRPD	=	X-ray powder diffraction

Prefixes *n*-, *s*-, *i*-, *t*- and *tert*- have their usual meanings: normal, secondary, *iso*, and tertiary.

Claims

1. A pharmaceutically-acceptable acid addition salt of a compound of formula I,



I

wherein

R^1 represents C_{1-2} alkyl substituted by one or more fluoro substituents;

R^2 represents C_{1-2} alkyl; and

n represents 0, 1 or 2.

2. A compound as claimed in Claim 1, wherein the acid is an organic acid.

3. A compound as claimed in Claim 2, wherein the acid is a sulfonic acid.

4. A compound as claimed in Claim 3, wherein the acid is 1,2-ethanedisulfonic acid, a camphorsulfonic acid, ethanesulfonic acid, a propanesulfonic acid, a butanesulfonic acid, a pentanesulfonic acid, a toluenesulfonic acid, methanesulfonic acid, *p*-xylenesulfonic acid, 2-mesitylenesulfonic acid, a naphthalenesulfonic acid, benzenesulfonic acid, a hydroxybenzenesulfonic acid, 2-hydroxyethanesulfonic acid or 3-hydroxyethanesulfonic acid.

5. A compound as claimed in Claim 3, wherein the acid is a C_{1-6} alkanesulfonic acid or an optionally substituted arylsulfonic acid.

6. A compound as claimed in Claim 4 or Claim 5, wherein the acid is ethanesulfonic acid, *n*-propanesulfonic acid or benzenesulfonic acid.

7. A compound as claimed in any one of Claims 1 to 6, wherein R^1 represents $-OCHF_2$ or $-OCH_2CH_2F$.

8. A compound as claimed in any one of Claims 1 to 7, wherein R^2 represents methyl.

9. A compound as claimed in any one of Claims 1 to 8, wherein n represents 0 or 2.

10. A compound as claimed in Claim 9, wherein, when n represents 2, the two fluoro atoms are located at the two *ortho*-positions relative to the point of attachment of the benzene ring to the $-NH-CH_2-$ group.

11. A compound as claimed in any one of Claims 1 to 10, wherein the compound of formula I is Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe).

12. A compound as claimed in any one of Claims 1 to 10, wherein the compound of formula I is Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(2,6-diF)(OMe).

13. A compound as claimed in any one of Claims 1 to 10, wherein the compound of formula I is Ph(3-Cl)(5-OCH_2CH_2F)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe).

14. A compound as claimed in any one of Claims 1 to 13 in substantially crystalline form.

15. A compound as claimed in any one of Claims 1 to 9, 11 or 14, which is Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe), ethanesulfonic acid salt.

16. A compound as claimed in Claim 15, characterised by a differential scanning calorimetry curve, at a heating rate of 10°C/min in a closed pan with a pinhole under flowing nitrogen, exhibiting an endotherm with an extrapolated onset temperature of about 131°C; and/or an X-ray powder diffraction pattern characterised by peaks with d-values at 16.5, 12.2, 9.0, 7.6, 6.2, 6.0, 5.9, 5.5, 5.4, 5.1, 4.66, 4.60, 4.31, 4.25, 4.19, 4.13, 4.00, 3.87, 3.83, 3.76, 3.72, 3.57, 3.51, 3.47, 3.31, 3.26, 3.21, 3.03, 2.74, 2.56, 2.50, 2.46 and 2.21 Å, and/or essentially as defined in Table 3 and/or in Figure 1.

17. A compound as claimed in any one of Claims 1 to 9, 11 or 14, which is Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe), benzene-sulfonic acid salt.

18. A compound as claimed in Claim 17, characterised by a differential scanning calorimetry curve, at a heating rate of 10°C/min in a closed pan with a pinhole under flowing nitrogen, exhibiting an endotherm with an extrapolated onset temperature of about 152°C; and/or an X-ray powder diffraction pattern characterised by peaks with d-values at 14.2, 12.6, 10.2,

7.5, 6.4, 6.3, 6.1, 5.9, 5.7, 5.4, 5.3, 5.1, 4.83, 4.73, 4.54, 4.50, 4.35, 4.30, 4.24, 4.17, 4.09, 4.08, 3.96, 3.91, 3.77, 3.62, 3.52, 3.31, 3.19, 3.15, 3.09, 3.00, 2.79, 2.76, 2.72, 2.59, 2.56, 2.54, 2.49 and 2.38 Å, and/or essentially as defined in Table 5 and/or in Figure 2.

19. A compound as claimed in any one of Claims 1 to 9, 11 or 14, which is Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe), *n*-propane-sulfonic acid salt.

20. A compound as claimed in Claim 19, characterised by a differential scanning calorimetry curve, at a heating rate of 10°C/min in a closed pan with a pinhole under flowing nitrogen, exhibiting an endotherm with an extrapolated onset temperature of about 135°C; and/or an X-ray powder diffraction pattern characterised by peaks with d-values at 12.4, 10.0, 7.5, 6.2, 5.8, 5.7, 5.4, 5.3, 4.78, 4.68, 4.51, 4.49, 4.40, 4.32, 4.29, 4.25, 4.19, 4.14, 4.07, 4.04, 3.94, 3.88, 3.73, 3.48, 3.28, 2.97, 2.54, 2.51 and 2.46 Å, and/or essentially as defined in Table 7 and/or in Figure 3.

21. A process for the preparation of a compound as claimed in any one of Claims 1 to 20, which process comprises addition of an acid to a compound of formula I as defined in Claim 1.

22. A process for the preparation of a compound as claimed in Claim 14, or any one of Claims 15 to 20 (as dependent on Claim 14), which process comprises crystallising a compound as claimed in any one of Claims 1 to 13.

23. A process for the preparation of a compound as claimed in Claim 14, or any one of Claims 15 to 20 (as dependent on Claim 14), which process

comprises a process as claimed in Claim 21 followed by a process as claimed in Claim 22.

24. A process as claimed in Claim 22 or Claim 23, which comprises crystallising the compound from a solvent.

25. A process as claimed in Claim 24, wherein the solvent is selected from the group: lower alkyl acetates, lower alkyl alcohols, lower dialkyl ketones, aliphatic hydrocarbons and aromatic hydrocarbons.

26. A process as claimed in Claim 24, which comprises dissolving a compound as defined in Claim 1 in amorphous form in a solvent selected from the group lower alkyl alcohols, lower alkyl acetates, lower dialkyl ketones, and mixtures thereof, and subsequent crystallisation.

27. A process as claimed in Claim 26 which comprises either:

(a) dissolving the compound in a lower alkyl alcohol, and then addition of a lower alkyl acetate or a lower dialkyl ketone; or

(b) dissolving the compound in a mixture of a lower alkyl alcohol and a lower alkyl acetate, or a mixture of a lower alkyl alcohol and a lower dialkyl ketone.

28. A process as claimed in Claim 27 wherein the solvents are selected from the group: methyl *iso*-butyl ketone, *iso*-propanol, ethyl acetate, *iso*-propyl acetate and mixtures thereof.

29. A process as claimed in Claim 24, which comprises a process as claimed in Claim 21, followed by direct crystallisation of the compound so

formed from a solvent system that comprises a lower alkyl acetate, a lower dialkyl ketone or a hydrocarbon.

30. A process as claimed in Claim 29 wherein the solvent system is selected from the group: *iso*-propanol, *iso*-propyl acetate, *n*-butyl acetate, toluene, methyl *iso*-butyl ketone, ethyl acetate and mixtures thereof.

31. A process as claimed in Claim 24, which comprises pre-forming compound of formula I in a lower alkyl alcohol, followed by addition of a lower alkyl acetate, a lower dialkyl ketone or a hydrocarbon.

32. A process as claimed in Claim 31 wherein the solvents are selected from the group: methanol, ethanol, *iso*-propanol, methyl *iso*-butyl ketone, *n*-butyl acetate, toluene, *iso*-octane, *n*-heptane, ethyl acetate and *iso*-propyl acetate.

33. A process for the preparation of a crystalline compound as defined in Claim 15 or Claim 16, which comprises slurrying pre-formed salt in either methyl *iso*-butyl ketone or a mixture of *iso*-propanol and ethyl acetate.

34. A process for the preparation of a crystalline compound as defined in Claim 15 or Claim 16, which comprises adding ethanesulfonic acid (optionally in the form of a solution in methyl *iso*-butyl ketone) to a solution of Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe) in methyl *iso*-butyl ketone.

35. A process for the preparation of a crystalline compound as defined in Claim 15 or Claim 16, which comprises adding ethanesulfonic acid to a

solution of Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe) in *iso*-propanol, and then adding ethyl acetate as antisolvent.

36. A process for the preparation of a crystalline compound as defined in Claim 17 or Claim 18, which comprises slurrying pre-formed salt in ethyl acetate, methyl *iso*-butyl ketone or *iso*-propyl acetate.

37. A process for the preparation of a crystalline compound as defined in Claim 17 or Claim 18, which comprises adding benzenesulfonic acid to a solution of Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe) in ethyl acetate and then adding *iso*-propanol to facilitate crystallisation.

38. A process for the preparation of a crystalline compound as defined in Claim 17 or Claim 18, which comprises adding benzenesulfonic acid to a solution of Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe) in *iso*-propanol and then adding ethyl acetate as antisolvent.

39. A process for the preparation of a crystalline compound as defined in Claim 19 or Claim 20, which comprises slurrying pre-formed salt in a mixture of *iso*-propanol and *iso*-propyl acetate, or in a mixture of *iso*-propanol and ethyl acetate.

40. A process for the preparation of a crystalline compound as defined in Claim 19 or Claim 20, which comprises adding *n*-propanesulfonic acid to a solution of Ph(3-Cl)(5-$OCHF_2$)-(*R*)CH(OH)C(O)-(*S*)Aze-Pab(OMe) in *iso*-propanol and then adding ethyl acetate, or *iso*-propyl acetate, as antisolvent.

41. A compound obtainable by a process according to any one of Claims 21 to 40.

42. A compound as claimed in any one of Claims 1 to 20 or 41 for use as a medicament.

43. A pharmaceutical formulation including a compound as defined in any one of Claims 1 to 20 or 41 in admixture with a pharmaceutically acceptable adjuvant, diluent or carrier.

44. A compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, for use as a pharmaceutical.

45. A compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, for use in the treatment of a condition where inhibition of thrombin is required.

46. A compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, for use in the treatment of a condition where anticoagulant therapy is indicated.

47. A compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, for use in the treatment of thrombosis.

48. A compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, for use as an anticoagulant.

49. The use of a compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, as an active ingredient

for the manufacture of a medicament for the treatment of a condition where inhibition of thrombin is required.

50. The use of a compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, as an active ingredient for the manufacture of a medicament for the treatment of a condition where anticoagulant therapy is indicated.

51. The use as claimed in Claim 49 or Claim 50, wherein the condition is thrombosis.

52. The use as claimed in Claim 49 or Claim 50, wherein the condition is hypercoagulability in blood and/or tissues.

53. The use of a compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, as an active ingredient for the manufacture of an anticoagulant.

54. A method of treatment of a condition where inhibition of thrombin is required which method comprises administration of a therapeutically effective amount of a compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, to a person suffering from, or susceptible to, such a condition.

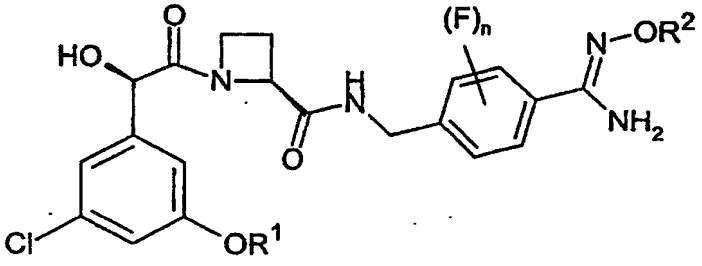
55. A method of treatment of a condition where anticoagulant therapy is indicated which method comprises administration of a therapeutically effective amount of a compound as defined in any one of Claims 1 to 20 or 41, or a pharmaceutically acceptable derivative thereof, to a person suffering from, or susceptible to, such a condition.

56. A method as claimed in Claim 54 or Claim 55, wherein the condition is thrombosis.

57. A method as claimed in Claim 54 or Claim 55, wherein the condition is hypercoagulability in blood and/or tissues.

ABSTRACT

There is provided pharmaceutically-acceptable acid addition salts of compounds of formula I,



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wherein R^1, R^2 and n are as defined in the description, which salts are useful as prodrugs of competitive inhibitors of trypsin-like proteases, such as thrombin, and thus, in particular, in the treatment of conditions where inhibition of thrombin is required (e.g. thrombosis) or as anticoagulants.

FIGURE 1

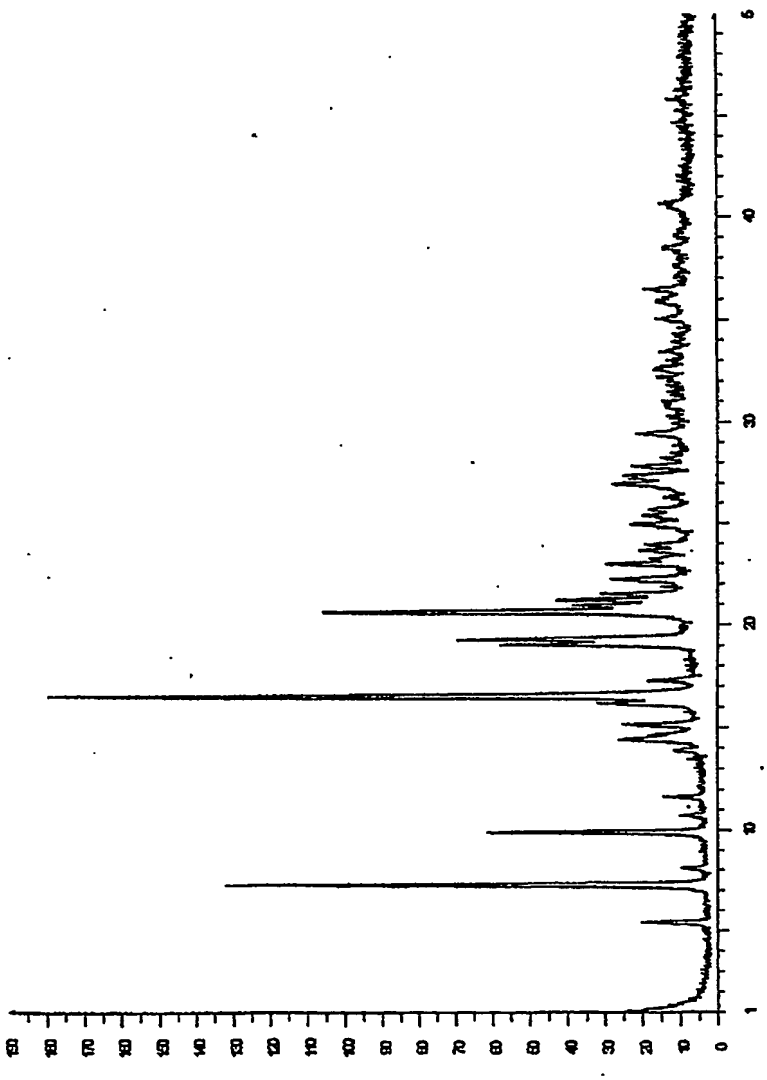

FIGURE 2

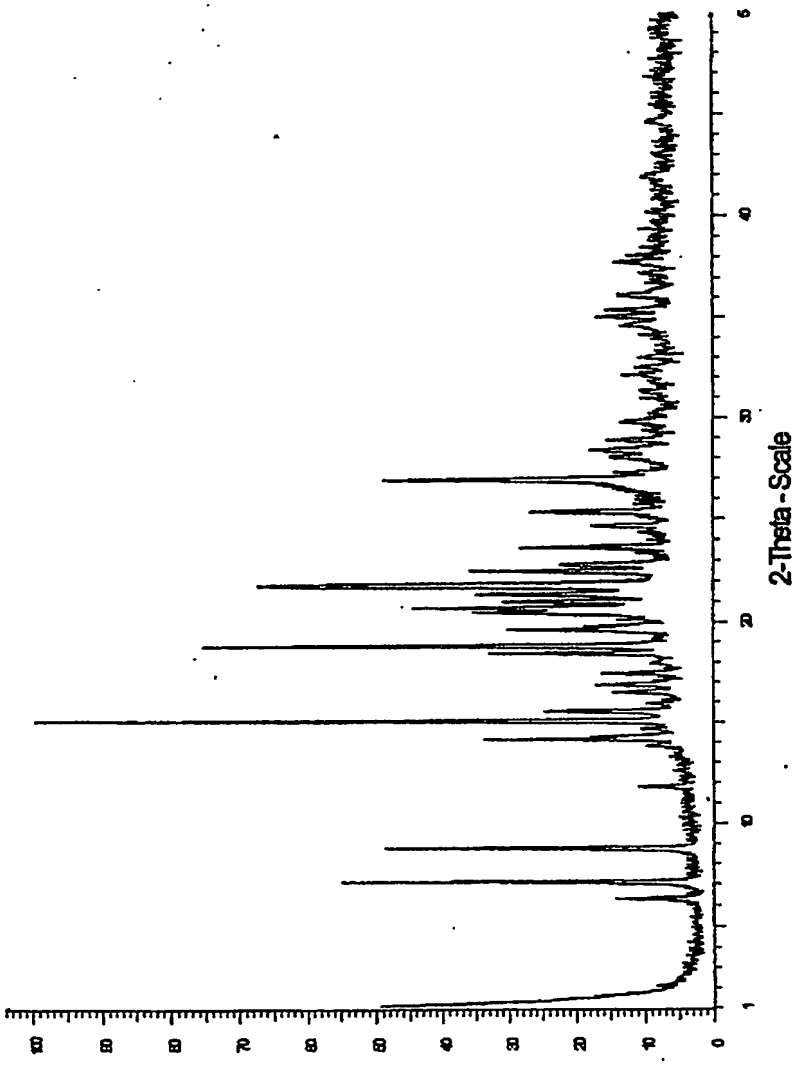

FIGURE 3